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ANALYSIS OF ENERGY RESOURCES AND PROGRAMS OF THE SOVIET UNION AND EASTERN EUROPE

Appendix C: Oil

Stanford Research Institute

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Appendix C. Oil.

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A. Oil Resources in the USSR

1. Introduction

Oil is an energy source whose importance has grown steadily in the Eastern European countries since World War II. Although there are large well-known oil deposits from which significant amounts of oil have been produced for some time, the discovery of new fields of great resource magnitude has added to the important place of oil in the total energy requirements of Eastern Europe.

Oil is the most versatile and essential fuel for modern industrial economies. Accordingly, oil resources and recoverable reserves are of major strategic importance. Recognizing this fact, the USSR and other Eastern European countries understandably regard such information as state secrets.* This practice presents a serious problem in analysis; the Institute has had to use indirect methods in estimating the magnitude of oil resources, with the possibility of inaccurate conclusions about the potentials for oil development in this area.

It was pointed out by Campbell[1] that "despite the lack of definite information on Soviet oil reserves, there is no shortage of confident estimates about their magnitude." Most of the recent statements in official Soviet sources are ambiguous, and are unquantified. Neither can the common index numbers or estimated percentage increases in oil reserves be employed with any confidence to build up a reserve estimate from pre-war data.[1]

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* For example, Soviet State Secrets Act of 1947.

The vast sedimentary regions of the USSR imply ultimate oil resources greatly in excess of those in the United States. These sediments have been scarcely explored, with the cumulative drilling per squire kilometer only about one-fortieth that of the United States. This difference would be even greater if the smaller amount of exploratory drilling had been compared (but Soviet data were not sufficiently broken down to permit this to be done). Campbell concludes his discussion of reserves by noting that "the oil is undoubtedly there, but the costs of finding and producing it will change in response to the changing geological and technical situation."

To examine the magnitude of Soviet oil resources, it is necessary to reason from data on the deposits characteristics. The discussion below will describe salient characteristics based on known information. Earlier estimates of oil resources will be discussed so as to set the framework of prior work in this area, and present-day estimates of Soviet oil resources will then be derived and discussed. Finally, the smaller but nonetheless important oil resources of the other CMEA countries will be examined.

2. Geology of Soviet Oil Resources

A brief description of the geology of Soviet oil resources is presented as an aid in analysis of the estimated resource base and recoverable reserves. The principal oil fields are in the Western Siberian Basin, the Volga-Ural Basin and Donets Basin of European Russia, and the Trans-Caucasus basins of the southern part of the country.

Table C-1 summarizes principal features of the major Soviet oil fields as of 1972. It can be seen that the largest reserves are found in the Samotlor field of the Western Siberian Basin, with the Romashkino field of the Volga-Ural Basin a close second in size. The table shows other geological information about these oil fields; some of the information is described below.

Table C-1

MAJOR OIL FIELDS OF THE USSR

Field	Year Discovered	No. of Wells	Million Barrels: 1971 Prod.	Million Barrels: Cumul. Prod. 1/1/72	Million Barrels: Est. Reserves 1/1/72	Pay Name	Pay Age	Pay Depth (ft)	API Gravity	Sulfur (wt-%)
Arlan	1955	2,000	95	485	4,100	Carb.	Carb.	4,134- 4,429	27.2	3.04
Balakhany-Sabunchi-Ramany	1869	-	14	1,567	3,500	Plio.	Plio.	300- 6,000	-	-
Bibi Eybat	1871	-	17	1,021	2,000	Plio.	Plio.	300- 6,900	-	-
Glynsko-Rozbyshev	1958	-	-	-	310	P.Carb.	P.Carb.	5,619- 5,745	-	-
Karachukur-Zykh	1928	-	-	-	600	Plio.	Plio.	660- 8,100	-	-
Korobki	1951	-	-	-	102	O.Carb.J.	O.Carb.J.	4,100- 5,740	42	0.25
Kuleshova	1958	-	-	-	759	O.Carb.P.	D.Carb.P.	1,755-10,860	41	0.70
Aliyurt et al	1915	-	102	1,315	3,000	K.Mio	K.Mio	1,500-10,200	34	0.20
Mamontovo	1965	-	-	-	3,000	K.	K	7,100- 7,798	27	1.51
Megion	1961	-	-	-	885	Jor.K	Jor.K	7,034- 8,016	34	0.65
Mukhanovo	1945	500	-	700	1,530	D.Carb P.	D.Carb. P.	1,050-10,007	38	1.0
Naftianye Kamni	1949	1,200	-	-	2,500	Plio.	Plio.	600- 5,406	25	0.2
Novoyelkhovo-Aktasn	1951	-	-	-	3,000	O.Carb.	D.Carb.	3,937- 5,577	32	1.2
Pravoinsk	1964	-	-	-	1,500	LK	LK	6,970- 7,877	-	-
Priluki	1959	-	-	-	660	L.Carb.	L.Carb.	5,889- 6,171	39	-
Romashkino	1948	5,000	-	-	14,310	Dev.	Dev.	5,725- 5,791	31.7	1.62
Samotlorskoye	1967	100	58	97	15,114	LK	LK	5,250	37.5	-
Salym	1963	-	-	-	1,000	K	K	7,200	-	-
Medvedev et al	1962	-	-	-	4,200	K	K	4,936-11,130	34	0.8
Sanghachaly-Duvanny	1963	-	14	28	900	Plio.	Plio.	[illegible]-11,880	-	-
Staro-Groznyy	1893	-	5	335	650	Mio.K	Mio.K	660-13,500	-	-
Shkapovo	1953	-	-	-	1,251	D.Carb.	O.Carb.	-	-	-
Tuymazy	1937	-	-	-	2,236	D.Carb.	D.Carb.	3,477- 5,610	33	2.0
Uzen	1961	580	54	139	4,860	Jor.	Jor.	2,667	33.9	0.20
Ust-Balyk	1961	100	-	-	3,100	LK	LK	-	29	1.0
USA	1963	-	-	-	614	Carb.P.D.	Carb.P.D.	4,020- 6,510	-	-
Yarino et al	1956	-	-	-	510	Carb.	Carb.	4,756- 6,070	41	0.6
Yuzhno-Cheremshanka	1969	-	-	-	1,140	K	K	5,100- 6,200	-	-
Zapadno-Surgut	1962	-	-	-	2,000	K	K	5,700- 6,900	29	1.2
Totals					119,223					

Source: International Petroleum Encyclopedia (1972) The Petroleum Publishing Co., Tulsa.

Table C-2 shows the distribution of Soviet oil deposits by reservoir type. More than four-fifths of all oil deposits occur in sandstones, with only minor amounts in limestones; still, limestone reservoirs are locally important, especially in Perm, Orenburg, and Tadzhidsk where they account for more than half of the total resources.

Table C-2

DISTRIBUTION OF SOVIET OIL RESOURCES
BY RESERVOIR TYPE
(Percent)

	Terrigenous (Sandstone)	Carbonaceous (Limestone)
RSFSR	85.3%	14.7%
Komi SSR	100.0	-
Tatar SSR	97.1	-

Table C-3 shows the distribution of oil resources of the USSR and its republics by depth of occurrence as of 1966. Although more recent discoveries may have changed this distribution somewhat, available (but incomplete) recent data suggest that the distribution is generally accurate. However, more recent drilling has emphasized greater depths, and it may be expected that there will be shifts in total resources toward these more deeply buried deposits. Probably, this work will have greatest effect on the depth zone statistics for the RSFSR, where most of the current drilling has been concentrated.

Table C-4 shows the distribution of Soviet oil resources by geological age. This table was constructed from data available in the latter 1960s and does not include more recent discoveries. In fact, the distribution of Soviet oil resources by geological age appears to have changed dramatically in recent years:[2]

Table C-3

DISTRIBUTION OF SOVIET OIL RESOURCES BY DEPTH ZONE (METERS)

(Percent)

	0-600 m.	601-1,200 m.	1,201-1,800 m.	1,801-2,400 m.	2,401-3,000 m.	3,001-3,600 m.	3,601-4,200 m.	4,201-4,800 m.
RSFSR	1.3%	15.3	68.9	9.1	3.5	1.9%	-	--
Ukraine	4.8	2.6	24.7	20.1	47.8	-	-	-
Turkmen	1.2	26.4	32.8	29.3	10.3	-	-	-
Uzbekistan	32.6	45.9	12.2	6.1	3.2	-	-	-
Tadzhik	55.9	44.1	-	-	-	-	-	-
Kirgiz	1.9	31.7	23.1	43.3	-	-	-	-
Azerbasian	21.8	30.9	28.2	9.5	0.3	2.9	3.2	0.3
Georgia	7.5	77.3	15.2	-	-	-	-	-
Kazakhstan	66.1	28.5	5.4	-	-	-	-	-
Moldavia	100	-	-	-	-	-	-	-
Total	6.4%	18.6	56.9	9.9	5.7	1.9	0.56	0.04%

Table C-4

DISTRIBUTION OF SOVIET OIL RESOURCES BY GEOLOGICAL AGE

(Percent)

	Paleozoic				Mesozoic				Cenozoic			Grand
	Devonian	Carboniferous	Permian	Total	Triassic	Jurassic	Cretaceous	Total	Paleocene	Neogene	Total	Total
RSFSR	51.7	35.0	2.5	89.2	-	1.5	1.1	2.6	3.8	4.4	8.2	100
Ukraine	-	3.7	3.6	7.3	2.2	1.2	-	3.4	88.6	0.7	89.3	100
Turkmen	-	-	-	-	-	-	-	-	-	100	100	100
Uzbekistan	-	-	-	-	-	0.5	3.9	4.4	75.0	20.6	95.6	100
Tapzhidsk	-	-	-	-	-	-	-	-	-	100	100	100
Kiroiz	-	-	-	-	-	-	2.3	-	97.7	-	97.7	100
Azerbasian	-	-	-	-	-	-	-	-	8.4	91.6	100	100
Georgia	-	-	-	-	-	-	-	-	-	100	100	100
Kazakhstan	-	-	9.4	-	-	21.8	68.8	-	-	-	-	100
Moldavia	-	-	-	-	-	-	-	-	-	100	100	100
Total	38.5	26.1	2.0	66.6	-	0.5	7.3	7.8	2.8	27.8	25.6	100

Estimated Crude Oil Resources (A+B+C)
(Percent)

Geologic Age	1 Jan. 1966	1 Jan. 1970	Net Change
Cenozoic	14.8%	13.0	- 1.8%
Mesozoic	24.2	50.0	+25.8
Paleozoic	61.0	37.0	-24.0

The bulk of the oil deposits of the USSR discovered in the Western Siberian Basin are of Mesozoic age. Thus, their effect on the total resources and on the percentage distribution has been dramatic. The geographic shift of the principal resource base is similarly dramatic, as Reference 2 points out: "the bulk of crude oil production (about 80 percent) takes place in European regions" at present. Shifts in productive capacity toward the east to take advantage of the newly discovered resources there will doubtless be attempted, although this is sure to be time-consuming and difficult to achieve.

The geographic and stratigraphic shifts in resource percentages reported by Soviet sources are enlightening in another way. The enormous new resources that lead to this statistical reversal have already been commented upon. Also of significance, and perhaps of even greater importance over the short term, is the fact that known resources in the currently developed fields of European Russia are demonstrated to be rather small. Many of these fields (such as the Baku area) have been in production for many years, and doubtless have been extensively depleted. Even allowing for the often optimistic Soviet practice of including marginal resources of C_1 category in this estimate, the real significance of this unprecedented change in resource base could well be in revealing the relatively short remaining productive lifetime of the European oil fields that have supplied Soviet needs for the past several decades and which are certain to be of great importance in meeting oil requirements of much of

the USSR and CMEA countries over the near term (i.e., at least until 1980). This situation will be examined in greater detail in a later section.

These recent shifts in oil distribution by geologic age are also evident in the estimated density of oil occurrence by tectonic structural type (Table C-5). The table shows that the greatest densities of oil resources are found in the young orogenic basins and geosynclines. The possible influence of geologic age on oil occurrence noted by many previous workers is again illustrated by these data. As noted earlier, however, the magnitudes of these oil densities are regarded with some skepticism because of the relatively sparse exploration in some key areas.

Table C-5

USSR TECTONIC OIL-BEARING STRUCTURES
AS RELATED TO GEOLOGIC AGE
(Thousand Tons per Km^2)

Structure	Ultimate Resources (10^3 tons/km^2)	Geologic Age: Paleozoic	Mesozoic	Cenozoic
Inner Syneclise	10			
Foredeep	40			
Orogenic Basins		<3	5	18
Synclinorium in Miogeosynclines		~3	~8	50
Middle Massifs	3-10			

Source: Nalivkin, 1972.

Brief geological descriptions* of the principal Soviet oil fields are presented below.

- West Siberian Basin. The West Siberian Basin is a topographic and structural depression covering about 1.8 million square kilometers located east of the Ural Mountains.[3] The terrain in much of the area is swampy and difficult, with muskeg in the south and permafrost in the north. The basemont rocks are igneous and metamorphosed Paleozoic rocks occurring at average depths of 3,000 to 4,000 meters. More than 114 oil and gas fields have been discovered in this basin. The productive strata are sandstones generally less than 10 meters thick, of late Jurassic and Cretaceous ages. The fields are on anticlinal structures, with irregular areas of closure; most industrial fields are of medium size.

  In general the oil fields are surrounded by water; but many do not leave a water drive, and production is by gas expansion. Table C-1 shows characteristics of the principal oil fields of the West Siberian Basin area.

  The ultimate recovery of oil from the West Siberian Basin, according to Dickey, "will certainly be over 73 billion barrels, and probably several times that."

- Volga-Ural Region. The Volga-Ural region covers 500,000 square kilometers along the eastern edge of the European Russian platform adjacent to the Ural Mountains which constitute its eastern margin.[4] Oil occurs as widely distributed deposits in Paleozoic (Devonian, Carboniferous, and Permian) sandstones and limestones that occur at depths ranging from 1,000 to 2,000 meters. Oil is also found in relation to salt dome deposits in the Pre-Caspian depression along the southeast part of the Russian platform. As noted earlier, this area contains several giant oil fields and has substantial reserves. Still, its total is not as great as that estimated for the West Siberian Basin.

  More than 500 oil fields have been found in this region. The main oil pools are in Devonian strata folded into anticlinal structures. As a rule, oil fields are confined to sedimentary rocks bordering massive reefs, although production is in some places from the reefs themselves.

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* Derived from N. A. Eremenko, G. P. Ovanesov, and V. V. Semenovich, "Status of Oil and Gas Prospecting in USSR in 1971," Assoc, Petroleum Geologists Bulletin, Vol. 56, No. 9, pp. 1711-1722.

- Timano-Pechora Region. This region is about 170,000 square kilometers in the northeast part of the Russian platform. A thick cover of Paleozoic sedimentary rocks covers the basement rocks. Commerical oil reservoirs are found in Devonian strata folded into anticlinal structures separated by broad depressions.

- Dnepr-Pripyat Area. This area occurs in the southwestern part of the Russian platform, and consists of two deep depressions, the Dnepr-Donets and Pripyat, which descend to 7 kilometers. The sedimentary rocks of Paleozoic and Mesozoic age have been extensively faulted into a system or horsts and grabens. Commercial oil deposits occur in Upper Paleozoic and Middle Mesozoic strata.

- Prebaltic Province. This area of 190,000 square kilometers occurs in the northwestern part of the Russian platform. Sedimentary rocks of Paleozoic age attain thicknesses of 4.5 kilometers. Five small oil fields have been found in Lower Paleozoic rocks, and further exploration is in progress.

- North Caucasus. This region covers 250,000 square kilometers between the Caspian Sea and the Sea of Azov. Mesozoic and Tertiary sediments ranging from 1.5 to 7 kilometers thick occur in this area. About 300 oil fields have been discovered in the area, most of them in anticlinal zones in the axial parts of foredeeps. Production is from Cretaceous and Cenozoic reservoirs.

- South Caspian. This province covers 100,000 square kilometers that straddle the Caspian Sea and is the oldest oil-producing region of the USSR. The province is made up of deep intermontane depressions filled with Mesozoic and Tertiary sediments that attain thicknesses to 16 kilometers. A total of 84 oil fields have been discovered in this area, and commercial production has come from reservoirs of Tertiary age. Extensive offshore exploratory drilling in the Caspian Sea has been undertaken in an attempt to extend present reserves.

- Central Asia. The Central Asia region covers about 1 million square kilometers between the Caspian Sea and Tien Shan. Mosozoic and Tertiary sedimentary rocks constitute the host rocks for oil. About 100 oil fields have been discovered, mainly on the flanks of large depressions.

- Siberian Precambrian Platform. This area covers more than 3 million square kilometers between the Yenisey and Lena Rivers. Sedimentary rocks preserved in downfolds or depressions may be favorable targets in exploration for oil fields, as in the vicinity of Lake Baikal.

- Far East. This province is essentially limited to the Sakhalin district, an area of about 600,000 square kilometers (including offshore deposits). Commercial oil occurs in Miocene sediments, and about 30 fields have been discovered in this area.
- Offshore. Exploration for offshore oil deposits in the USSR has been concentrated in the Caspian Sea (mentioned earlier) and in the Sea of Azov and the Black Sea. Geophysical surveys have been undertaken as a first step toward examination of the prospects for development of the Baltic Sea, Barents Sea, Kara Sea, and the Sea of Okhotsk.

3. Estimates of Soviet Oil Reserves

a. General

As noted ealier, the Soviets do not publish estimates of oil reserves in their country. However, there have been several estimates of oil reserves in the USSR in terms of "known" or "proved" reserves, where production is in progress or where production can be anticipated. Table C-6 summarizes several important recent estimates of oil reserves in

Table C-6

COMPARISON OF REPRESENTATIVE PREVIOUS ESTIMATES OF SOVIET OIL RESERVES

Source	Year	Reserves (billion barrels)
Hodgkins	1961	66
World Oil	1969	58
U.S. Geological Survey	1971	73
Halbouty et al	1970	84
Klemme	1971	76
International Petroleum Encyclopedia	1972	119

the USSR.* The similarity in these reserve estimates is remarkable, in view of the uncertain situation owing to sparse or totally lacking data from Soviet sources. The more recent estimates are larger than the earlier ones, reflecting (at least partly) the recent oil discoveries. Still, these estimates are for recoverable reserves, and do not purport to describe the total oil resource base of the USSR. This will be the subject of the following section.

b. Estimates of Oil Resources

A gross estimate of the amount of recoverable oil in the USSR may be calculated rapidly from the area and depth of sedimentary cover, assuming that oil occurrence is roughly proportional to the volume of sediments. Approximately half the USSR is promising for oil and gas exploration; this is nearly 12 million square kilometers.[5] To this area must be added the 7.6 million square kilometers of possible offshore oil areas.[6] Thus, the total area of the USSR favorable for oil and gas occurrence is nearly 20 million square kilometers. Assuming an average sediment thickness of 3 to 4 kilometers, as reported by the referenced workers and others, and an average oil content of 12,000 barrels per cubic kilometer, the estimated oil resources of the USSR are found to be between 720 and 960 billion barrels. This is nearly an order of magnitude greater than the resources of the United States (see Figure C-1).

The relatively shallow depths assumed in the above calculation are considered reasonable in light of recent Soviet data. With particular reference to the Western Siberian province, it was noted that:

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* A summary of earlier estimates was given by J. A. Hodgkins (Soviet Power, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1961). This listing is intended to supplement that work.

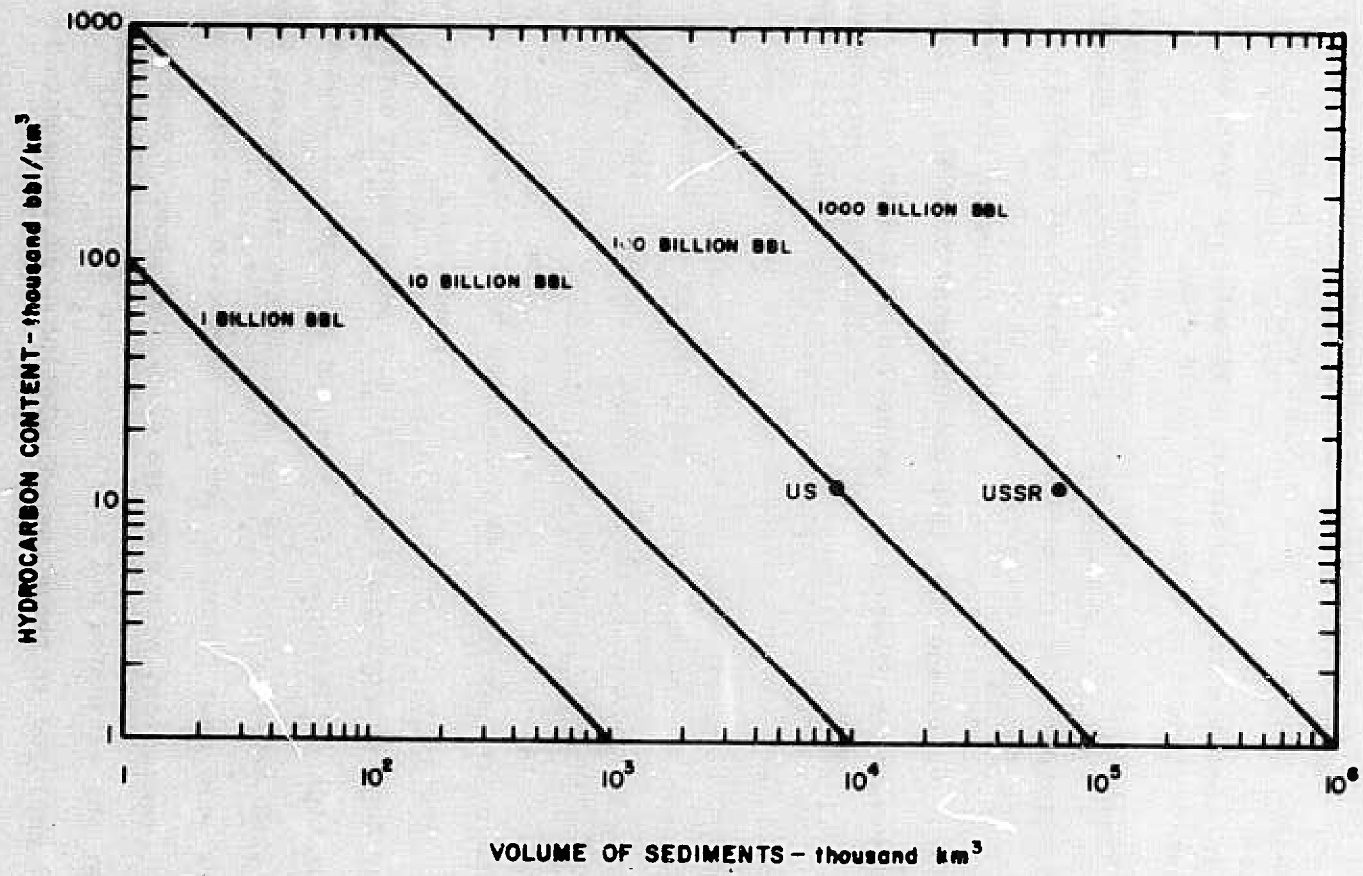

Figure C - 1

ESTIMATED CRUDE OIL RESOURCES FROM RELATIONSHIP OF HYDROCARBON CONTENT TO SEDIMENT VOLUME

". . .in the lower horizons of the sedimentary cover, and reflecting the great depths and high temperatures, gas and gas-condensate beds must be absent. . . The bulk of crude oil reserves are associated with comparatively shallow depths. At depths of 2,400 meters and less there is to be found 83 percent of the reserves of crude oil abroad and 89 percent of the reserves of the USSR; at depths to 3,000 meters, these shares increase to 94.4 percent and 96.1 percent, respectively. In the central portion of Western Siberia, having in mind the high geothermal gradient, the crude oil zone must disappear at a depth of about 4 km.[7]

"Accepting for the entire platform a geothermal gradient of 3.3 to 4.2 degrees (C) per 100 meters (average 3.7 degrees per 100 meters)(it is assumed) that at depths of 2,400 to 2,700 meters thermal catalysis begins, leading to a destruction of normal crude oils, and transforming these crudes into light crudes and then into gas-condensate beds."

"For Western Siberia. . . at depths of 2.0 to 2.5 km and below, the sandstone(s) are subject to significant epigenetic changes, in essence worsening their collector properties (for crude oil)."

Because of these factors, which appear to restrict most crude oil occurrence to relatively shallow depths, we have used an average depth of 3 to 4 kilometers in these calculations.

The petroleum resources calculated by the volumetric method of Weeks et al. are less than those resulting from using a similar method developed by Russian geologists.[8] Table C-7 shows Soviet estimated resources by type of Tectonic structure and average thickness of sediments. Structures with medium complexity and sedimentary thicknesses from 2 to 5 kilometers were most favorable for the formation and occurrence of oil and gas, consistent with what was described above. However, as the table shows, the estimated oil occurrences are approximately 2 to 6 times the density employed in the above calculation. If these data were adopted, the estimated oil resources of the USSR would be truly astronomical. However, these data were derived for sedimentary areas

Table C-7

DISTRIBUTION OF PETROLEUM RESERVES OF THE USSR

Tectonic Structure	Definition	Ultimate Resources (tons/km^2)	Average Resources (tons/km^2)	Average Thickness (km)	Average Resources (tons/km^3)	Average Resources (barrels/km^3)
Syneclise	Negative or depressed structure on continental platform	20,000 to 50,000	31,000	3.0	10,330	74,373
Aulocogens	Fault-bounded intra-cratonic trough or graben	To 60,000	~30,000 (est.)	10	3,000	21,600
Internal Syneclise	Middle part of platform	3,000 to 10,000	10,000	3.4	2,941	21,175
Orogen Basins		1,000 to 18,000				
Middle Geosynclines		3,000 to 10,000				
Recent Geosynclines		Up to 50,000				

Source: Nalivkin, 1972.

that have been incompletely explored, with a possible consequence that the estimates are excessively influenced by the few known and rich deposits of oil. As more complete information becomes available, it is believed that estimated oil densities will become more consistent with those for better known deposits elsewhere in the world.

There seems to be no particular technical reason apparent at present why Soviet oil deposits should be so much richer than those occurring in other areas. Nevertheless, the possibility must be acknowledged that special conditions may occur in the USSR, and for this reason Nalivkin's data[8] are worth noting. If his density values were representative of actual resource conditions, then the ultimate oil resources of the USSR in place would be in excess of 5 trillion barrels; in view of the above-stated reasons, this value is regarded as quite unlikely. In particular, in view of the data cited earlier on the depth of deposits, the depths of useful deposits employed in Nalivkin's estimates (as well as those used here) may be too great, artificially increasing the resource estimates.

The character of sediments and their structural relations must also be considered. Variations in rock type occur laterally and vertically, influencing the total volumes favorable for petroleum occurrence. This method seeks to refine the volumetric method by inclusion of these critical factors. Meyerhoff[9] has employed seismic records for each sedimentary basin of the USSR, together with data on drilled and undrilled structures evident on aerial photographs, to arrive at an estimate of oil and gas reserves. These data are useful for comparison with those determined from the volumetric method. Table C-8 shows Meyerhoff's data for estimated oil and gas resources of the USSR. The table indicates that the amount of estimated oil resources are consistent with that derived from calculations based on sedimentary volume. Thus, the total oil resources of the USSR may be estimated by

Table C-8

ESTIMATED OIL AND GAS RESOURCES IN THE USSR
(from Meyerhoff)

	Potential Oil Resources (million bbl)	Potential Gas Resources (10^2 ft^3)
European Russia		
PreCarpathian Foredeep	5-600	5-6
Crimea	50	1
Baltic Platform	100	?
Dnepr-Donets	3,000	42
Pripyat	500-1,000	1-2
Trans-Caucasus		
Rioni Basin	50	0.1
Kura/S. Caspian/Trans-Caspian	30,000	30-40
North Caucasus Foredeep	20,000	60-80
Central Asia	80,000	1,000
Aral Sea	50,000	-
Emba Salt Basin	10,000	20
Volga-Urals	100,000	455
Pechora Basin (incl. offshore)	100,000	2,000
West Siberian Basin and Kara Sea	300,000	3,000
Taymyr Peninsula and Laptev Sea	20,000	1,100
Anabar Basin	1,000	10
Vilyvy Basin (Lena Valley)	500-1,000	150
Irkutsk Basin and Far East	20,000	100
East Siberian Sea	200,000	500
Anadyr Basin	100	20
Khatyrka Basin	500	20
Kamchatka	2,000	20
Amur River	1,100	22
Sakhalin	5,000	10
Fergana Basin	100	2
Totals	945,000 to 946,100	8,590 to 8,623

this method to be in the general range of 850 billion to 950 billion barrels. This estimate is consistent with the two previous estimates based on volume of sedimentary rocks and characteristics of potential oil-bearing structures:

Source	Estimated Oil Resources (billion barrels)
Structural Method (Meyerhoff)	945
Volumetric Method (SRI)	720-960
Recovery Method (SRI from Klemme)[10]	850-950

Not all the estimated oil in place can be recovered. As one example, Levorson[11] cites the estimated reserves of the Bradford field of Pennsylvania as follows:

	Million Barrels	Percent
Primary natural production	250	16
Secondary recovery from water flooding	490	32
Tertiary recovery	800	52
Total	1,540	100

Thus, only about 16 percent of the total recoverable reserves in this field were from primary natural production. The total primary and secondary recovery is 48 percent for this field, higher than that found generally; the current overall recovery efficiency of U.S. oil reserves is about 32 percent (including primary and secondary).[12] As a rule of thumb, it appears that about one-third of the currently achieved production is primary, with the remaining two-thirds of recoverable reserves requiring secondary recovery methods for their production.

The above data, however, are derived from U.S. deposits, and care must be exerted in attempting to apply this experience to the Soviet deposits. It seems clear that the state of Soviet oil recovery technology

is less developed than that used in the Western World, with the result being that the overall recovery efficiency from Soviet deposits is probably lower than that achievable elsewhere. If it is assumed that Soviet production technology is four-fifths as efficient as that of the United States, the overall total oil recovery from deposits of the USSR would be about 25 percent of the total reserves. Assuming further that total Soviet oil recovery consists of production from both primary and secondary recovery as in the United States,* it is concluded that only about one-third the total (roughly 8 to 10 percent) represents primary production, with the remainder requiring secondary recovery.

The above data can be employed, together with a recent estimate of Soviet oil reserves for primary recovery (Table C-9), to check the earlier calculations as to the magnitude of the total oil resources of the USSR. The reserves in giant and supergiant fields suitable for primary recovery are estimated to total 76.2 billion barrels. On a world scale, giant fields account for over 80 percent of the resources. If this percentage distribution (or one close to it) applies for the USSR, then another 19 billion barrels or so might occur in smaller fields, bringing the total primary recovery reserves to about 95 billion barrels. More probably, however, giant fields represent a greater share of Soviet oil resources than do such fields on a world scale. Assuming that the giant fields represent as much as 90 percent of the oil resources of the USSR, only about 8.5 billion barrels would occur in smaller fields, with the total primary recovery reserves being about 85 billion barrels. At least, these estimates would appear to bracket the reserve estimates.

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* This assumption is supported by data that indicate Soviet practice of secondary recovery technology. See, for example, R. A. Ioanessian, "Progress in World Oil Production," Seventh World Petroleum Congress, Vol. 1B, pp. 93-108, Mexico 1967.

Table C-9

GEOLOGY OF GIANT OIL FIELDS OF THE USSR BY BASIN TYPE

	Intracratonal (Syneclise)	Grabens (Aulocogens)	Extracontinental (Orogen Basins)	Intermontane (Internal Syneclise)	Estimated Oil Reserves (billion barrels)	
					Primary Recovery	Total Resources
2-2 Volga-Ural	x				20.3	
2-3 Pechora	x				1.0	
2-4 West Siberian	x				30.2	
2-18a Kansu	x				1.2	
2-18c Dzungaria					3.5	
2-18d Tsaidam						
3-23 Dnieper-Donets		x			0.7	
3-24 Bukhara-Tadzik		x			4.0	
3-25 Ver Khayand-Vilyuy		x			0.7	
3-26 Heilung Kiaug		x			0.7	
4-28 Mangyshlak-Turkmen			x		12.9	
6-42 Baku				x	0.9	
Total					76.2	

Source: Klemme, 1972.

Regarding the portion of total resources represented by primary recovery, it is assumed for ease in calculation that these represent about 10 percent of the total.

For purposes of this analysis, therefore, it is concluded that the USSR's oil resources are as follows:

		Billion Barrels	Billion Metric Tons
1.	Resources in place (ultimate reserves)	950	132
2.	Recoverable reserves (primary and secondary recovery at 25 percent of total resources)	240	33.3
3.	Reserves for primary recovery (at 10 percent of total)	95	13.2
4.	Primary recovery reserves in giant oil fields (at 80 percent of total primary recovery reserves)	76	10.5

It is estimated that the distribution of primary recovery reserves in the giant oil fields is distributed among the principal sedimentary basins as shown in Table C-9. The table shows that 30.2 billion barrels of oil for primary recovery occur in the West Siberian Basin (about 39 percent of the total primary recovery reserve). About 21.3 billion barrels occur in the basins of European USSR (28 percent of the total). At projected 1990 rates of consumption, if forced to meet the needs of the USSR and the other CMEA countries, the oil fields of European USSR are estimated to contain enough primary reserves for only 23 years. Therefore, owing to the relatively small size of these deposits and their relatively low remaining reserves compared to projected possible demands, it is reasonable to conclude that without augmentation of oil supply from newly developed Siberian fields or from imports from the Middle East, the USSR and associated CMEA countries face

an energy shortage over the near term that could conceivably approach crisis proportion to rival that being experienced by the United States. The potential influence of this prospective situation on Soviet policy and strategy will need to be examined carefully in planning for future international relations.

B. Oil Production in the USSR

Oil production during the period 1960 through 1971 in the USSR increased steadily at a rate of about 8.2 percent per year, to 377,075 tons (Figure C-2 and Table C-10). During this same period the amount of oil drilling in meters also increased steadily, at a rate of about 4.6 percent per year, to 12,128,000 meters in 1971 (Table C-11).

In 1970, about 80 percent of oil production was from the RSFSR with lesser amounts being produced in the remaining nine republics (Table C-12).

Several notable trends are apparent in the petroleum industry statistics:

- Prior to 1960 the percent of oil produced from flowing wells increased to a peak of about 74 percent (Table C-13). Since then production from flowing wells has declined (to about 57.7 percent by 1968), and this decline has been offset by an increase in oil produced by pumping or artificial lift. From the information available, secondary recovery in 1968 accounted for less than 2 percent of total production. This trend is as expected for an area where a significant portion of the oil produced is from new fields. As the area matures, the percentage of oil produced by artificial lift and secondary recovery methods will increase. The information on flowing wells may be somewhat misleading because waterflooding and pressure maintenance are highly developed in the USSR. In 1969, 160 of the 465 producing fields were being waterflooded, and 72 percent of production was claimed to be from water flooded fields. Depending on the pressure applied via water injection, the wells might flow and be classified as flowing wells.

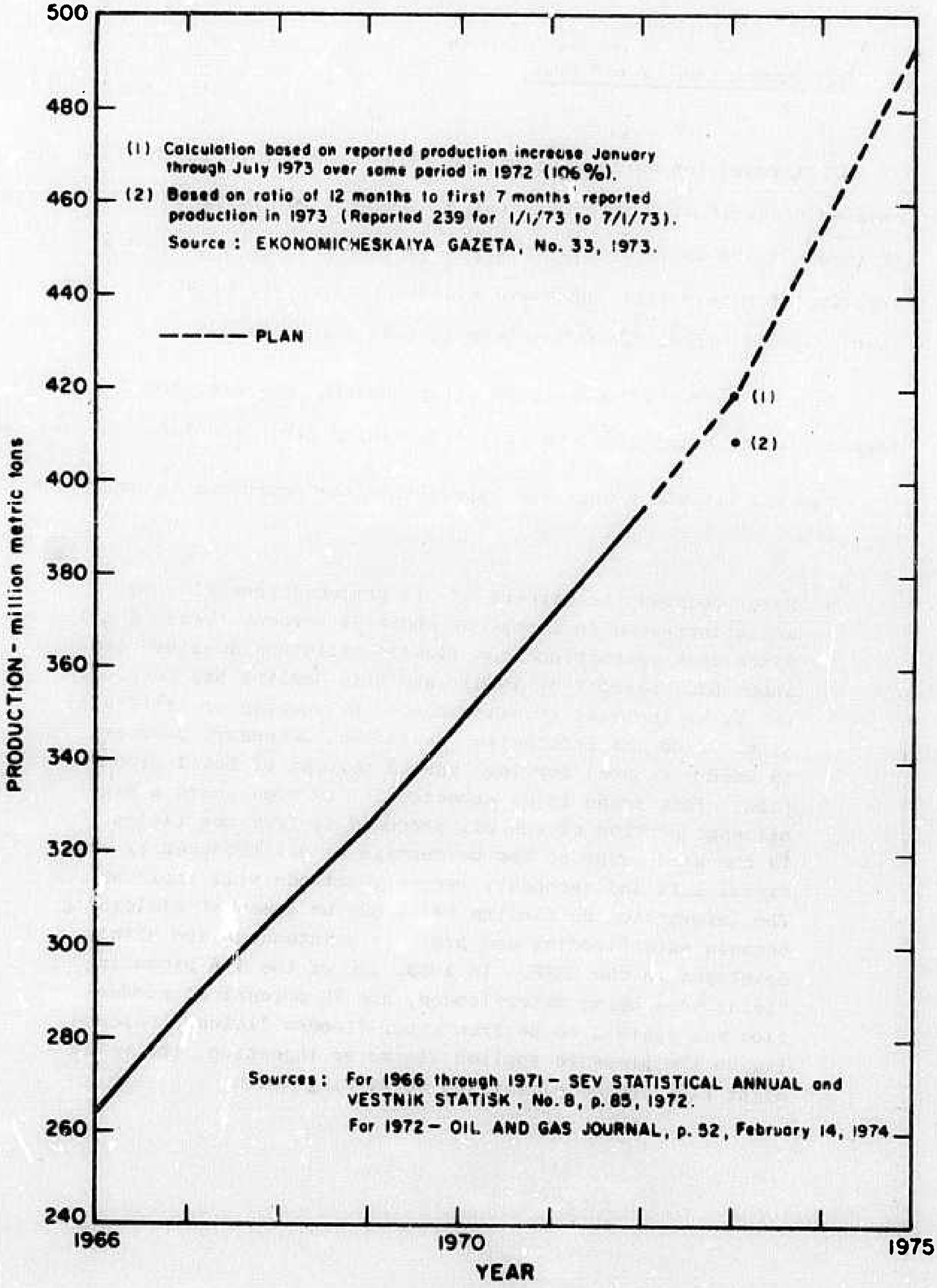

Figure C-2

USSR OIL PRODUCTION (LESS CONDENSATE)

Table C-10

USSR OIL PRODUCTION* FROM 1950 TO 1965
(Thousand Tons)

Year	Production	Year	Production
1950	37,878	1966	265,125
1955	70,793	1967	288,068
1960	147,859	1968	309,150
1961	166,068	1969	328,373
1962	186,244	1970	353,039
1963	206,069	1971	377,075
1964	223,603	1972	394,000†
1965	242,888	1975 (Plan)	496,000

* Including gas condensate.

† From Ekonomicheskaya Gazeta, N.G., February 1973.

Source: Narodnoie khoziaistvo (National Economy), Statistical Annuals of the Central Statistical Bureau of the USSR, 1922-1972.

Table C-11

WELL DRILLING, OIL AND GAS--USSR
(Thousand Tons)

Year	Total Drilled	Total Drilled Operational	Total Drilled Deep Exploration
1950	4,283	2,156	2,127
1955	5,012	2,770	2,242
1960	7,715	3,692	4,023
1961	8,363	3,830	4,533
1962	8,873	4,065	4,808
1963	9,148	4,287	4,861
1964	10,003	4,687	5,316
1965	10,716	5,151	5,565
1966	11,251	5,603	5,648
1967	11,707	5,905	5,802
1968	11,070	5,959	5,111
1969	11,061	6,137	4,924
1970	11,890	6,744	5,146
1971	12,128	6,878	5,250

Source: Narodnoie khoziaistvo (National Economy), Statistical Annuals of the Central Statistical Bureau of the USSR, 1922-1972.

Table C-12

USSR OIL PRODUCTION BY REPUBLIC
(Thousand Tons)

	1940	1950	1960	1965	1969	1970
RSFSR	7,039	18,231	118,861	199,929	265,653	284,288
Ukraine	353	293	2,159	7,580	13,351	13,909
Belorussia	--	--	--	39	2,760	4,234
Uzbekistan	119	1,342	1,603	1,800	1,799	1,805
Kazakhstan	697	1,059	1,610	2,022	10,124	13,161
Gruzia	41	43	34	30	26	24
Azerbaijan	22,231	14,822	17,833	21,500	20,420	20,187
Kirghizia	24	47	464	305	286	298
Tadzhikstan	30	20	17	47	155	181
Turkmenia	587	2,021	5,278	9,636	13,725	14,487
Total	31,121	37,878	147,859	242,888	328,299	352,574

Source: Narodnoie khoziaistvo (National Economy), Statistical Annuals of the Central Statistical Bureau of the USSR, 1922-1972.

Table C-13

OIL EXTRACTION IN THE USSR BY METHOD

	Percent of Total		
Method of Extraction	1940	1960	1968
Fountain flow	23.3%	73.7%	57.7%
Pumps	38.4	23.5	40.3
Compressors	37.2	2.3	1.8
Other	1.1	0.5	0.2
	100.0%	100.0%	100.0%

Source: Energeticheskyi Baland (Energy Balance), 1971.

The literature[13] indicates that the emphasis in production technology has clearly been on ultimate recovery; therefore, any comparison based on numbers of flowing wells, production per day, and other measures used in U.S. industry practice versus USSR practice can be misleading.

- Capital investments in the petroleum industry have been increasing steadily at about 8.5 percent annually since 1950 (Table C-14) but this rate is below the rate of capital investment increase for the industry as a whole, which is about 9.5 percent.

- There is significant emphasis in the literature on economics, especially on the components of prime costs, on the reduction of prime costs, and on growth rates of labor productivity (Tables C-15, C-16, C-17, and C-18). Generally, cost improvement has been related to economy of scale and to some basic evolutionary changes in operating procedures. For example, subsurface pumps (once common in the USSR, but seldom used in the United States) were replaced by surface pumps with electric motors. In general, these changes in operating procedures have reduced downhole repairs and have therefore contributed to lower operating costs.

Table C-14

CAPITAL INVESTMENTS OF FUEL ENERGY INDUSTRY--USSR
(Million Rubles)

	1950	1960	1965	1966	1967
Oil and Gas Industry	652	1,330	2,339	2,539	2,604
Coal Industry	630	987	1,207	1,250	1,281
Electroenergetics	369	1,422	2,144	2,237	2,337
Total	1,651	3,739	5,690	6,026	6,222
Whole Industry	4,177	12,639	17,616	18,237	19,460

Source: M. B. Rabin, Toplivo i Effektivnost' Yevo Ispol' zovania (Fuel and Effectiveness of its Utilization), Moscow 1971.

Table C-15

COMPONENTS OF PRIME COST IN OIL AND GAS PROCESSING INDUSTRY--USSR

Components	Percent of Total in 1965
Energy costs	5.3%
Wages of industry workers	5.1
Amortization of drilling	31.1
Amortization of additional drilling	10.0
Repairs	8.4
Expansion of oil producing layers	11.1
De-emulsation	4.6
Intra-industrial transfer	5.6
Collection and transportation of gas	2.5
Departmental expenses	7.4
Other	8.9
	100.0%

Source: M. Brenner, Ekonomika Neftianoi i Gazovoi Promyshlennosti SSR (The Economics of Oil and Gas Industry in the USSR), Moscow, 1968.

Table C-16

DECLINE IN OIL PRODUCTION COSTS IN THE USSR
BY REPUBLIC

(Percent Cost in 1965 Relative to 100 Percent
Cost in 1955)

	% Cost 1965 Relative to 100% Cost 1955
RSFSR*	
1 cubic meter oil	16.5%
1,000 cubic meters gas	27.0
RSFSR	45.6%
Azerbaijan	83.1
Kazakhstan	100.0
Ukraine	24.0
Turkmenia	62.0
Uzbekistan	87.0

* RSFSR - Russia.

Source: M. Brenner, Ekonomika Neftianoi i Gasovoi Promyshlennosti SSSR (The Economics of Oil and Gas Industries in the USSR) Moscow, 1968.

Table C-17

LABOR PRODUCTIVITY OF OIL INDUSTRY IN THE USSR

	1961-65	1966-70
Growth Rates (percent)		
Oil production	163.8%	144.4%
Oil production per 1 worker	143.6	133.4

	1960	1965	1970
Production (tons)			
Oil production per 1 worker	1,652	2,373	3,166
Average monthly yield of 1 well	371	510	589
Operating labor (people per day)	2.60	2.46	2.13
Rate of decrease (percent)		94.60	86.60

Source: Neftyanoye Khozialstvo, N.5, 1972.

Table C-18

GROWTH INDICATORS OF LABOR PRODUCTIVITY IN THE USSR BY OIL REGIONS--1971

Oil Regions	Number of Regions	Percent of Total Production	Growth of Production (percent)	Oil Production per Worker: Tons	Oil Production per Worker: Compared to 1970 (percent)	Labor Expenses per Well: Workers per Well	Labor Expenses per Well: Compared to 1970 (percent)	Average Annual Wages: Rubles	Average Annual Wages: Compared to 1970 (percent)
1. New regions	4	17.2%	+37%	9,860	119.5%	2.93	81.8	3,034	110.0%
2. Old with increasing production	14	67.4	+ 3	4,283	103.0	2.26	95.4	1,756	103.8
3. Old with stable or decreasing levels of production	8	15.4	- 2	1,258	98.8	1.76	97.2	1,783	102.8

Source: Neftyanoye Khoziaistvo, N. 5, 1972.

C. Exploration, Development, and Production

1. Geophysics and Geology

Although the Oil and Gas Journal[14] estimates that the USSR is technologically 10 to 20 years behind the West, there is no indication that such a technological lag will inhibit Soviet ability to produce petroleum products or will deter attainment of Soviet production goals. It is indicated that Soviet geophysical tools and data reduction technology are not as highly developed as Western tools and techniques but the basic principles of seismography, magnetics, and gravity measurement are highly developed and well-known. Perhaps the convenience aspect of Western tools and computer technology is overrated since these do not necessarily provide better analysis, nor do these technological advancements allow researchers to do anything unique--they are simply devices for interpreting basic geophysical and geological data faster and with less manpower. The rate at which petroleum is being found and developed in the USSR indicates that its basic exploration tools (geology and geophysics) are sophisticated enough to implement the plans now underway. Furthermore, since the development of a petroleum industry in the USSR is in its beginning, one can anticipate rapid improvements in application and operation technology as experience increases. Geological analysis will certainly improve as the subsurface geology data base increases with each new well drilled, as is the case in all producing areas of the world.

Although pertinent literature is sparse, one can only conclude that the basic sciences of geology and geophysics are as advanced in the USSR as elsewhere in the world, and that although their implementation tools may not be as sophisticated as some developed and used in the West, this technology lag will not be a deterrent to finding additional petroleum reserves.

In one technical paper a Russian author[15] was quite critical of coordination between operations and technical developments, citing, for example, that much technology effort was devoted to development of jet bits; yet pumps compatible with these bits were not available until some eight years after the bits were available. Undoubtedly, there are many similar instances in this rapidly expanding industrial segment. Certainly, technological and operating advancements will not occur uniformly throughout the industry.

2. Drilling

The USSR has been the world leader in the development and use of the turbo drill in petroleum drilling. By 1956, 70 percent to 75 percent of the petroleum drilling in the USSR employed this method. Today the percentage is even higher. The benefits of the turbo drill are that the drilling power source is located near the bit, and therefore much less power is consumed than in more conventional rotary drilling where the drill pipe is turned at the surface. In rotary drilling, large power losses are sustained as the entire length of the drill pipe is turned with the bit, often several thousand meters below the power source. The turbo drill is especially well-suited for directional drilling, and the method is used, although infrequently, in the United States. The major disadvantage of the turbo drill is that when the bit becomes stuck in the hole, the entire turbo drilling mechanism may be lost. This disadvantage has been a major reason for its limited use in the United States.

To meet goals established for 1975 (reference 16), deeper drilling will be essential, and costs are expected to increase about 50 percent over 1970 costs as drilling time per well is expected to increase with the increase in average depth (40-50 percent). To offset rising

costs, the industry is experimenting with means of increasing productivity by decreasing number of bit rotations while increasing axial load. The most satisfactory results have been within the limits of 150-250 revolutions/minute. Light metal drill pipe is also being introduced to reduce rig deadweight lifting requirements. There is considerable emphasis, throughout Soviet petroleum drilling literature, on efforts to reduce weight and associated power requirements in the drilling system. Furthermore, there is more emphasis on bit technology than might normally be expected, especially in hydro-monitored bits that use fluid under pressure to provide a combination hydraulic drilling and bit drilling effect.

Technologically, this bit development is closely related to turbo drilling technique, and the emphasis is on cost reduction by reducing numbers of bit replacements. In addition, extensive efforts are being made to develop bits that will not need to be replaced during the drilling operation. The diamond bit, used less and less in the West, is used frequently in the USSR, and there is active research to increase its performance. Virtually all the problems of deep drilling (greater than 15,000 feet) and super-deep drilling (greater than 20,000 feet) are discussed at length in the literature relative to the 20 super-deep wells being drilled in current programs. The technical innovations mentioned most frequently are:

a. Reactive turbo drills (394 to 1,020 millimeters).

b. Welded drill stem shanks.

c. Turbo-diamond drilling.

d. Low noise heading motors.

e. Aluminum alloy drill pipe.

f. One and three cone bits with spherical bearings.

g. Thermostable drilling fluids.

Of these, items a, c, and e are associated with turbo drilling not used in the West, but items b, f, and g are within the state of the art in the West. Item d is more difficult to evaluate because the term "Low Noise" is too general to provide a basis for assessment.

For the most part, the problems cited in Soviet literature are not problems in the West to the extent that they limit capability. The problems most frequently stated--hydro-explosion, well bore durability, and deformation of the rock being drilled--are related to drilling mud, bits, and the use of the turbo drill. In other words, some of the Soviet drilling problems are precisely the reason that turbo drills are not used in the West. In addition, the USSR might be deficient in drilling-mud technology. Some of the drilling-mud additives used in the West are quite sophisticated.

No doubt, improvements can and will be made, but these improvements will be evolutionary rather than revolutionary.

The USSR has also placed what seems to be an unusual amount of emphasis on automated drilling and the devices associated with drilling. The Oil and Gas Journal of March 9, 1970 reports on "Russian Automated Rig Finishes Test Program," and this test program could be the beginning of a new era in Soviet drilling since the emphasis is clearly on technical achievement. Automated and partially automated rigs have been built and tested in the United States from time to time, with the usual conclusion that the maintenance labor requirement tended to offset the operating labor requirement. Eventually such a rig will probably be the industry standard but the timing is questionable. Since the Soviets list the major advantages of the automated unit as better performance, reduction in skilled drill crew, and lowering of personnel drilling skill (three interrelated factors closely associated with driller capability), a shortage of well-trained personnel might give impetus to automation development.

In addition to drilling techniques that are currently within the state of the art in the USSR, there is considerable literature emphasis on electro-drilling and vibration drilling.

The electro-drill unit consists of an electric motor of small diameter but considerable length with two connections: to a bit, and to the lower end of the drill-pipe column. The drilling mud is forced down the drill-pipe column in the conventional manner. The major problem that has prevented otherwise satisfactory commercial development has been the cable for energy (electricity supply). Soviet engineers predict major successes for this method when it is successfully developed.

Vibration drilling is another new Soviet concept that employs a mechanical vibration exciter; this induces sufficient vibration and sound to decrease adhesion forces within the rock, thereby causing it to disintegrate as the device progresses. These units are being used as prospecting tools drilling to depths of only 25-30 meters.

3. Offshore Petroleum

The USSR's deepest offshore well was drilled in the Caspian Sea to a total depth of 18,383 feet in 1972 (reference 17). It took 17 months to complete the well where seven previous attempts were abandoned because of lost circulation and other mishaps. Storms, delays in equipment delivery, and a stuck drill string also complicated the job. The Soviets have not emphasized offshore drilling, and as a result, their capability has not progressed as rapidly offshore[18] as onshore. The reasons are obvious and focus on the vast undeveloped land area and the complexity of offshore versus onshore operations. Certainly Western know-how in offshore operations is being observed by the USSR, and Western assistance may be essential to short term success in this endeavor.[19]

4. Production Techniques

Procedures for oil and gas well completion are about the same as in the West, and the descriptions of well testing prior to completion are quite similar to the procedures followed in the West. The primary differences would be in hardware, but there have recently been purchases of U.S. produced supplies--especially pumps. Reda Pump Co., Bartlesville, Oklahoma, is supplying several hundred pumps having a value of about \$20 million; they are electrically powered centrifugal down-hole pumps in the 150-216 hp rating range, with associated instruments, spare parts, tools, and materials for service and repair.[20] Reda is also training Soviet personnel at Bartlesville, and Reda personnel provide supervision in Russia. Byron Jackson, Corporation, a subsidiary of Borg-Warner, is also selling about \$6 million in down-hole pumps. These are in the 165 hp class[21] for use in wells to 9,000 feet deep, producing crude with severe admixture of sand, hydrogen sulfide, and paraffin to operate in bottomhole temperatures of 200°F and surface temperatures to -65°F. Certainly the USSR is interested in the purchase of selected oil field equipment to supplement its own products. Thus far, it has purchased U.S. manufactured blowout preventers, gas-lift equipment, valves, christmas trees, and pipe benders[22] in addition to the very recent purchases of pumps. The Soviet market potential is large compared to other world markets but small compared to the U.S. market. Currently the USSR has about 1,800 rigs at work drilling about 40 million feet of hole per year; this probably amounts to 5,000-6,000 wells per year in addition to the existing producing wells (probably about 70,000).

Again, as in geophysics and drilling, the completion technology in the USSR has been on an internal development basis without major benefit of Western know-how. Undoubtedly the USSR could benefit more substantially if it had access to more Western experience, and in some instances, the West might gain knowledge from some Soviet developments,

but the technology gap is not a factor in the USSR's capability to find prospects, drill wells, complete wells, and produce petroleum. The improved technology of the West is more related to convenience, productivity, and overall cost.

Production techniques in the USSR are directed to optimize recovery. Water flooding is highly developed and usually commences, where applicable, in the very early stages of development to provide reservoir pressure maintenance throughout the life of the field. Water flooding is a factor in about two-thirds of Soviet oil production and the Soviets estimate that ultimate oil recovery has increased by a factor of 2 to 2.5 (reference 6) because of this emphasis on early water injection.

Since only a portion of the world's petroleum reservoirs are suitable for water injection, the success claimed by Soviet engineers is probably more related to inherent reservoir characteristics than to any specific technology. The benefits of water flooding, as well as the related technology, are certainly well-known in the West.

5. Casing Head Gas Storage

An urgent requirement in the USSR has been for a means of storing wet gas at the well site until it can be delivered to markets. Storage is especially a problem in remote areas where refineries and gas pipelines are not available to use the wet gases associated with oil. The literature indicates that considerable progress has been made in the methodology for returning the wet gases to the gaseous zone (upper portion) of the reservoir, and in the recovery of those gases at a later date when they can be used.

6. Trends in Drilling of Wells

Trends in Soviet drilling of oil and gas wells can be seen in Table C-11. In recent years, the rate of exploratory drilling has increased

substantially, to the point where it exceeded operational (production) drilling in 1960, and continued to do so for six years. However, in 1967 the amount of exploratory drilling (in thousand meters) was slightly less than the amount of production drilling; in 1971 the amount of exploratory drilling was some 20 percent less than that of production drilling. A possible reason for this is the seasonal exploration work in the West Siberian Basin, so that on a yearly average, the drilling appears to be artificially slow.

7. Secondary Recovery Techniques

Probably the most unique aspect of oil recovery from the large oil resource in the USSR is that whenever possible, secondary recovery techniques are mainly used along with primary recovery development efforts at the initiation of oil field development. This dual operation permits the Soviets to recover large percentages of the oil from the reservoir--a reported 50-70 percent.[23] Basically, the USSR employs water flooding techniques at the earliest development stages of the reservoir to keep tl formation pressure at sufficient levels to maximize the recovery of the resource.

Over time, a number of water flooding systems have been developed in the USSR.[24] These are discussed below.

a. Peripheral Water Flooding

The oldest of all types of water flooding techniques applied from the very beginning of oil field development is the method of peripheral water flooding. Using this method, all of the injection wells are located in actual water zones beyond the oil-water contour--beyond the limits of the oil pool. In this case, the development process is nearer the mechanism of a pool under natural water-drive conditions with active edge water. Peripheral water flooding only intensifies the normol recovery processes by increasing the oil displacement with water under pressure. This technique is particularly applicable to

to small oil pools with active edge water, since it accelerates the development process and can decrease the cost of primary oil production. The Tuimazy oil field in Bashkiria is a prime example of peripheral water flooding used at the initial development stage of the reservoir. One of the earliest peripheral water flooding applications was begun by the Soviets in 1946-1947.

b. Marginal Water Flooding

When peripheral water flooding began, the Soviets tried to locate the injection wells relatively far from the oil-water contour. After studying the hydrodynamics of the flooding process and having field experience, the Soviets located the injection wells close to the external oil-water contour--i.e., along the upper bedding plane of the oil productive bed. This is how the name "marginal flooding" was derived. The approach of the injection zone to the withdrawal zone allowed the current oil production to increase significantly for the same pressure drop because of the decrease of the normal filtration drawdown resistances. The increased effectiveness of this method relative to peripheral water flooding was especially observed in oil fields with reservoir rock properties deteriorating beyond the oil-water contour. Such conditions are characteristic of a series of oil fields in Azerbaijan, Kuibyshev, and other regions.

c. Internal Water Flooding with Division of Oil Pool

Marginal water flooding could not provide the necessary rate of development for very large oil pools and fields where decreased permeability of reservoir rock and sharp deterioration of reservoir rock characteristics beyond the oil-water contour were observed. For this reason, water injection began to be projected through wells situated within the limits of the oil-bearing region. While applying internal

flooding, the feeding contour region was not located close to the oil-water contour as in the case of peripheral water flooding, but was located directly in the oil pool as a series of lines or chains of injection wells. Thus, the oil pool was artificially "cut" into separate areas exploited relatively independently. The number of production wells located in the zone effectively maintained the pressure in the immediate vicinity of the injection wells and sharply increased the well flow rates. Thus, oil production increased and development time for the field decreased. A typical example of internal water flooding is the development of the Romashkino oil field with Devonian productive beds in Tatar ASSR. Here, the large oil pool was divided into 23 areas for independent development in 1952 to 1954. (The development of this field by peripheral water flooding only, under conditions of providing high oil recovery and using modern technology, was projected to require several hundred years of development.) The application of internal water flooding allowed the main reserves of oil to be recovered during 30 to 40 years, providing a 60-70 percent recovery of the reserve. This system will also be applied to other large developments.

d. Transverse Division of Oil Pools

This development is a type of internal water flooding, which employs injection wells drilled along lines perpendicular to the long axis of the oil pool. Between these rows of injection wells, from three to seven rows of production wells are situated; thus, the oil pool is cut or divided into several areas or blocks. This system is particularly effective in situations where the reservoir rock properties beyond the limits of an oil pool are observed to sharply deteriorate at the water-oil contact zone.

e. Longitudinal Division of Oil Pools

For comparatively wide oil pools, the longitudinal division method of internal water flooding was developed. Division of these oil pools by an axial internal line of injection wells considerably increases the number of producing wells located in the proximity of the injection wells. This causes the average well flow rate to increase, and the time of the field development is reduced. Axial water flooding is used, and is projected to be used, for oil fields that are characterized by sharply decreased rock permeability beyond the limits of the oil pools.

f. Areal Water Flooding

In oil pools with very poor reservoir rock properties but with beds capable of receiving injected water, areal water flooding is carried out. The process is not used as a secondary development method after a continuous exploitation, but is applied from the very beginning of the development--as a primary process. When areal water flooding is used, the distance between production and injection wells becomes a minimum. From the point of view of achieving a maximum well flow rate, this is the most effective method of water flooding. However, at present the application of this method (where it is not necessary) is excluded because of the increase in production of water and because of the possible danger of decreasing overall oil recovery.

g. Water Flooding Research Areas

Studies and tests continue to be made on using polymers, compounds containing surfactants, and foams to increase the efficiency of water flooding systems. The literature indicates that these are more expensive and less widely used than conventional methods.

h. Use of Miscible-Fluid Displacement Systems

Capillary forces can be eliminated by expelling the oil with miscible fluids such as liquefied petroleum gases, natural gas at high pressure, and other appropriate solvents. For economical reasons, it is necessary to form fringes of these solvents and to move these fringes by means of water or dry gas. It has been suggested that fringes of fluids soluble in both oil and water, such as alcohols and carbon dioxide, should be tried.

Since 1964, an experimental, commercial-scale injection of light hydrocarbons has been applied in the USSR for creating a fringe of solvent in a low permeability zone in the Minnibayevo area of the Romashkinskoye field. The calculated volume of the fringe of solvent (principally propane) is about 10 percent of the formation's pore volume. Dry gas is used to drive the fringe.

Experimental work on oil displacement from a reservoir by solvent is also being conducted in the Budafa field of the Hungarian People's Republic.

Field experiments in the USSR have shown that the method of driving oil by solvents sufiers by comparison with water flooding, since the solvent-driven system seems to form fingers of areas where the solvent breaks through the deposit.

From the literature, it appears that the USSR is continuing to examine the miscible-phase drive systems for oil recovery, but that these systems are still a relatively small effort when compared with other techniques. The economics of any such venture obviously depend on complete recovery or maximum recovery of the valuable solvent.

i. Secondary Recovery of Petroleum Reserves by Thermal Methods

Among the new oil field exploitation methods designed to raise the recovery factor of the oil, the widest application, especially of late, is the thermal stimulation methods. These are most effective in the exploitation of fields containing heavy crudes.

Thermal recovery methods are employed for stimulating both the bottomhole zone and the formation as a whole. Thermal stimulation of the bottomhole zones with electric heaters, hot-water circulation devices, and subsurface gas burners is carried out in the USSR and Romania as well as in the United States, Austria, and the Netherlands. However, this method is slow and the introduction of heat into the formation is not too effective, it is used principally for cleaning the filtration zone from paraffins, waxes, and other materials.

Recently, steam injection has been widely used.[24] Heating the bottomhole zone of formations by steam improves the wettability of rocks, and the low-permeability zones become soaked with water that drives the oil from them into the high-permeability zones. Cleaning the filter and pores from waxes and other deposits is also ensured with this technique. At various conditions, the heat consumption per steam treating cycle of a well is 10 to 15 million calories per meter of effective bed thickness. The average rate of steam injection is one to two tons per hour, at a steam pressure ranging from 20 to 150 kilograms/square centimeters and steam temperature from 200 to 250°C. An average steam generator capacity varies from 2 to 5 million calories per hour.

Economic characteristics of hot water and steam treatment of formations are greatly influenced by the rate of heat loss in the well bores. Calculations show that deep wells give greater heat losses; therefore, steam and hot water systems are preferably injected into shallow formations.

Another method of thermal recovery is the direct combustion of oil in situ. The first field tests of this method were made in the USSR more than 35 years ago. In the following years, more profound theoretical and experimental investigations of this method were carried out. In the last decade, field experiments on stimulation of oil production by means of creating intraformational centers have been conducted around the world and only recently, if at all, in the USSR. It appears that combustion techniques have not been widely used there.

The use of nuclear explosives to stimulate the production of oil and gas in the USSR appears to be still in the experimental stages of development.[25]

8. Summary

In the USSR, all new oil fields having considerable oil reserves but lacking an active natural water drive to maintain the planned recovery rate are developed by means of secondary recovery techniques applied at initiation of the development. These are mainly water flooding techniques. The injection of water into the productive formations began at the earliest development stage, thus allowing the recovery factors of 50-70 percent to be attained. High recovery factors are of major importance to the USSR's oil industry. It has been reported that in 1966, of 360 oil fields being developed, 110 were using water injection techniques. From 1963 to 1966 (the most recently available data), about 70 percent of the USSR's total oil production was from formations exploited by repressuring methods.

Current trends are aimed at maintaining or improving this level of performance. For example, in Bashkiria, a principal oil production region in the eastern part of the USSR, the current five-year plan calls for the maintenance of a production level of 40 million tons per year of oil up to the end of 1975. Since these reserves began development over

40 years ago, many of the larger and most productive wells have reached the point where production is peaking and beginning to decline. It is the hope that increased application of water flooding techniques can help the region achieve its desired production level, but such application is considered a difficult task. Since extraction of oil from these deposits, where the maintenance of formation pressure is carried out, accounts for 93 percent of the total crude output, it is expected that new discoveries will be more efficiently exploited by the use of water flooding techniques in order to offset the decline in productivity from the old wells.[26]

D. Transportation of Oil

1. Overview and Statistical Data

The transportation of crude oil and petroleum products in the USSR is currently shared about equally by pipelines and the railroads, with ocean, river and truck transport sharing the remainder. Table C-19 shows this distribution of transport between the various modes as of 1970. As shown, pipelines carried 46 percent of total shipments (mostly crude oil) and the railroads carried 41 percent of total shipments (largely petroleum products).

However it is only within the past decade, from 1962 on, that pipelines have grown rapidly. Prior to that, the railroads had handled about two-thirds of the total freight turnover (ton-kilometers) of petroleum and petroleum products transported in the USSR. Until the rapid expansion of Russian oil output in the past decade, pipelines were relatively minor carriers, accounting for 18 percent of total tonnage and only 6 percent of total turnover (ton-kilometers) of oil and oil products in 1950. Table C-20 quantifies the changes in oil transportation since 1950.

Table C-19

USSR PETROLEUM AND PETROLEUM PRODUCTS SHIPMENTS BY TRANSPORT MODE - 1970

Transport Mode	Shipments (million metric tons)	Percent
Pipeline	340*	46
Rail	303†	41
Ocean (ship)	35‡	5
River (ship or barge)	34	4
Truck	29	4
	741	100

* Consisting of 315 million metric tons of crude oil and 25 million metric tons of products.

† Largely products (80 percent of all product movements are by rail; 8 percent of product movements are by pipeline).

‡ Cabotage. Total, including exports to other countries, was 93 million metric tons. Hence, exports via ocean shipment were 58 million metric tons. Total ocean shipments were 12 percent of total, including exports.

Table C-20

USSR SHIPMENTS OF PETROLEUM & PETROLEUM PRODUCTS
BY TRANSPORT MODE FROM 1950-1970
(Millions of Metric Tons)

Transport Mode	1950	1955	1960	1965	1970	1975
All railroad shipments	43.2	77.6	~150*	221.2	301.5	410.0
Crude only	14.1	15.6	~37*	~53*	~84*	~105*
Pipeline shipments						
Crude	12.6	45.3	115.4	205.3	314.6	
Products	2.7	6.4	14.5	20.4	25.3	
Total	15.3	51.7	129.9	225.7	339.9	
All river shipments	11.9	14.4	18.5	25.1	33.6	
All ocean shipments	15.8	23.0	~34	~54	93.2	
Cabotage	n.a.	n.a.	~26.1	~30.5	34.8	

n.a. - not available.

* SRI estimate.

From the data given in Table C-20 the average annual growth rates in shipments of oil and oil products by the several modes of transport over the 1950-1970 period may be determined. These comparative growth rates have been:

Rail shipments of oil and products	10.2%/year
Pipeline shipments of oil and products	16.8%/year
River shipments of oil and products	5.3%/year
Ocean shipments of oil and products	9.3%/year

Pipelines have exhibited the greatest growth rate in shipments over the 20-year period, resulting in an increase in their share of total oil transport from 18 percent of total in 1950 to 46 percent of total in 1970. Until 1960, however, pipelines had been relatively neglected in the USSR. The reasons are not entirely clear although certain explanations have been proposed, such as the long standing deficits in steel pipe production and the dispersed nature of flows, particularly product flows, in the USSR. Also, the refinery mix in the USSR is characterized by a relatively high proportion of residual fuel output which is not suitable for shipment by pipeline. The result is that pipeline transport has been primarily used for crude oil shipments. Growth of crude oil pipelines and oil transport by this mode are summarized in Table C-21. From Table C-21 it can be determined that the length of oil pipelines increased at better than 10 percent per year over the 20 year period, 1950-1970. The tonnage of crude transported over that period increased at the rate of nearly 18 percent per year, from about 13 million metric tons in 1950 to 315 million metric tons in 1970. Products tonnage also grew at nearly 12 percent per year, though from a smaller base. Ton-kilometers of crude transport increased at 25 percent per year while ton-kilometers of products transport grew at 13 percent per year. The average length of haul for crude grew about 7 percent per year from 1950 to 1970, while for products there was very little growth in haul length. This lack of

Table C-21

GROWTH OF OIL PIPELINES IN THE USSR - 1913-1970

Parameter	1913	1928	1940	1945	1950	1955	1960	1965	1970	1971	Average Annual Growth Rate 1950-1970 (percent)
Length of main oil pipelines (thousand kilometers)	1.1	1.6	4.1	4.4	5.4	10.4	17.3	28.2	37.4*		10.2%
Flow, crude and products (million meter tons)											
Crude only			6.8	4.0	12.6	45.3	115.4	205.3	314.6	325.7	17.5
Products only			1.1	1.6	2.7	6.4	14.5	20.4	25.3	26.9	11.9
Total			7.9	5.6	15.3	51.7	129.9	225.7	339.9	352.6	
Freight turnover (billion kilometer-tons)											
Crude only			2.8	1.4	2.9	10.6	40.4	129.2	259.8	305.9	25.0
Products only			1.0	1.3	2.0	4.1	10.8	17.5	21.9	22.6	12.7
Total			3.8	2.7	4.9	14.7	51.2	146.7	281.7	328.5	
Average length of haul (kilometers)											
Crude only			417	361	230	234	350	629	826	939	6.6
Products only			880	762	739	648	745	857	864	840	0.8
Cost of pipeline transport (Kopecks/kilometer-ton)											
Crude only					.229	.205	.120	.103	.096		-4.3
Products only									.164		

* 30.7, crude oil only.

growth again merely reflects the fact that pipeline product hauls are small in quantity and dispersed in nature. The cost of transmitting crude by pipeline has apparently decreased by about 4 percent per year since 1950; however, there is no correction for the effects of inflation in the values given in the Soviet statistics. Rail shipments, too, have grown steadily at 10 percent per year, despite giving up a portion of their share of total transport. The growth in ocean transport is largely because the Soviets have made definite decisions that their growing oil exports to foreign countries should be carried in USSR vessels. Cabotage, on the other hand, has grown very little--approximately 2 percent/year over the period. River transport of oil has grown at only a modest rate and is of diminishing relative importance.

The several modes of transport have been allocated different functions in terms of carriage of crude versus products. As shown in Table C-20, pipelines have developed primarily as crude oil carriers, whereas railroads have been increasingly assigned the task of petroleum products carriage. In 1950 about one-third of the total rail shipments of oil and oil products was crude. By 1970 this share had dropped to an estimated 28 percent. Thus, even though pipelines have taken over a larger share of a greatly increased total crude transport, the railroads still have had to handle increasing amounts of crude because of this greatly increased oil traffic generated by burgeoning oil production and use in the USSR. Total oil and products shipments in the USSR have grown at an annual average rate of nearly 12 percent/year in the 20-year period, 1950-1970.

Oil shipments by river transport are primarily product movements. This is also true for ocean cabotage movements. Exports to foreign countries by sea, however, are largely crude oil.

River traffic in oil products is primarily on the Volga-Kama River system and the Caspian Sea-Volga route. Movement is from the

Trans-Caucasus, the Turkmen SSR, and the Volga producing areas to the Central and Northwestern regions. There is some reverse shipment of Volga-Ural crude to refineries in the Trans-Caucasus and some high-sulfur fuel oil shipment from the Volga-Urals refineries to the Trans-Caucasus for boiler use. The Volga River accounts for 80 percent or more of all river shipments of oil products.

Seaborne oil transport carries both products and crude oil. Cabotage shipments are mostly products and occur primarily on the Black Sea and the Caspian Sea. The main flows of these products in the Black Sea are from Novorosiisk, Tuapse, and Batum to Odessa and Feodosia in the Crimea. On the Caspian Sea, the shipment of refined products is from Baku to Makhachkala, Astrakhan, Guriev and Krasnovodsk. There is also a reverse flow of products from the refineries at Krasnovodsk to the Volga River ports.

Crude oil cabotage movements include those from Novorosiisk, Tuapse, and Batum to the smaller refineries at Odessa and Kherson. Some crude is shipped from Novorosiisk and Tuapse to Batum. There is also a flow of crude from Baku to Makhachkala to make up a shortage for the refineries at Groznyi. There is a reverse movement of crude by ship from Krasnovodsk to Makhachkala. The oil from offshore Caspian sea wells at Neftianye Kamni is taken by ship to Baku.

There is still relatively little short distance truck movement of oil products in the USSR. This is in sharp contrast to the United States where trucks carry about 7 percent of total crude shipments and more than a third of total product shipments. However the ninth five-year plan (1971-75) calls for the increasing use of products pipelines to transfer fuel shipments from rail and river transport; and for the shifting of short-haul rail shipments to tank trucks.

Table C-22 shows the 1970 crude oil production in the USSR by major oil basin and the economic region in which the basin is located. As shown, the oil producing fields in the Volga economic region are currently the greatest producers in the USSR. The great increase in production from these fields and the Urals fields has come since World War II. The total increment in oil production in the USSR between 1945 and 1965 was 224 million metric tons, of which the Volga-Urals areas contributed about 171 million metric tons.

Prior to World War II, more than 90 percent of total production came from the Caucasus. This area, however, recovered only slowly from the damage and shut-downs of the war. Since then, improved technology, such as increased depth-drilling and offshore Caspian Sea drilling, has enabled the Caucasus, since about 1960, to once again contribute to oil production growth.

The areas that are currently becoming the greatest growth areas for oil production are Western Siberia and the Mangyshlak Peninsula areas on the Caspian Sea in Kazakhstan.

As would be expected from the foregoing, the significant movements of crude oil and products in the USSR occur between the areas of great production (i.e., the oil fields of the Volga-Urals economic regions, the Caucasus, and more recently the West Siberian fields and the Turkmen fields of Central Asia) and the areas of heavy consumption in the central and western portions of the USSR. The post-World War II increase in output from the Volga-Ural fields has decreased the importance of transport flows from the older fields in the Caucasus. The postwar trend in interregional movement has been to transport crude oil, preferably by pipeline, from the producing fields to refineries located in the demand centers. This represents somewhat of a reversal in general Soviet policy, which had previously aimed at locating primary processing centers

Table C-22

CRUDE OIL PRODUCTION IN THE USSR - 1970

	Basin and Region	Production (million metric tons)
I.	Tatar fields (Almetyeosk) (Volga region)	101.0
	Bashkir fields (Tuimazy) (Volga region)	41.0
	Kuibyshev fields (Volga region)	35.0
	Lower Volga fields (Volgograd, Saratov) (Volga region)	7.0
II.	Perm fields (Urals region)	16.0
	Western Orenburg fields (Urals region)	8.0
	Udmurtia fields (Urals region)	1.0
III.	Chechen-Ingush fields (Troznyi) (Northern Caucasus)	20.5
	Stavropol fields (Northern Caucasus)	6.5
	Krasnodar fields (Northern Caucasus)	5.5
	Daghestan fields (Northern Caucasus)	2.0
IV.	West Siberian fields (West Siberian)	31.5
V.	Azerbaijan fields (Caucasian region)	20.0
	Georgian fields (Caucasian region)	0.5
VI.	Turkmen fields (Central Asia)	14.5
	Usbekistan fields (Central Asia)	2.0

Table C-22 (Concluded)

Basin and Region	Production (million metric tons)
Kirghizian fields (Central Asia)	0.25
Tadshikistan fields (Central Asia)	0.25
VII. Kazakhstan fields (Emba & Mangyshlak fields) (Kazakhstan)	13.5
VIII. Eastern Ukrainian fields (Southwestern region)	11.5
Carpathian fields (Southwestern region)	2.0
IX. Mosyr fields (Byelorussia)	4.0
X. Ukhta fields (Northwestern region)	6.0
XI. Okha fields (Far Eastern region)	2.5
Total	352

near the raw material sources. However, as noted earlier, oil had been from the beginning much closer to demand centers than other energy fuels. The significance of Western Siberian finds and developments have somewhat changed this picture, since these fields are at considerable distance from the central areas. However, industrial and population growth in that region has generated significant demand there, too.

The maps interspersed in the following pages show the major transport routes and modes of transport of oil from the major producing fields to the refineries, and from the refineries to the consuming areas. The modes of transport shown include crude and products pipelines, rail

lines, river routes, and ocean ports and routes. The discussion accompanying each map includes such factors as the economic and industrial significance of the cities receiving crude and products; the distance between major centers; the amounts of oil and products received (where known); the name of the particular pipeline/rail system; the capacity and throughput of the pipelines where available; the location and capacity (where known) of major storage points in the system; the number of compressor stations (where known); and major take-off points to distribution centers.

Each discussion of transport from, and within, each producing region concludes with statements about the amounts of oil use compared to other fuels, and about the end-use pattern for oil in the region. Available information is noted regarding comparative delivered costs and the trends in transport likely to result from Gosplan policies.

2. Volga Oil Transport

Oil transport respecting the Volga region is presented in two maps, Figures C-3 and C-4. In the text, numbers after cities refer to the numbers given on the maps.

Oil was first discovered in the Volga Urals oil region in 1929 in the workers' town of Verkhnechusovskie Gorodki (1) on the river Chusovaya, but prior to the war, no more than 1 million tons (7 million barrels) of oil per year were produced in this region. After the war, however, the exploitation of the Volga oil fields increased at a dramatic rate: to 15 million tons per year in 1950 and 184 million tons (1.3 billion barrels) in the year 1970, which was nearly two-thirds of the total amount of crude oil produced in the entire USSR for that year.

The main producing areas in the Volga region are: the Volgograd (2) and Saratov (3) oil fields, which produced 7 million metric tons (49 million barrels) of oil in 1970; the Tataria oil fields in the

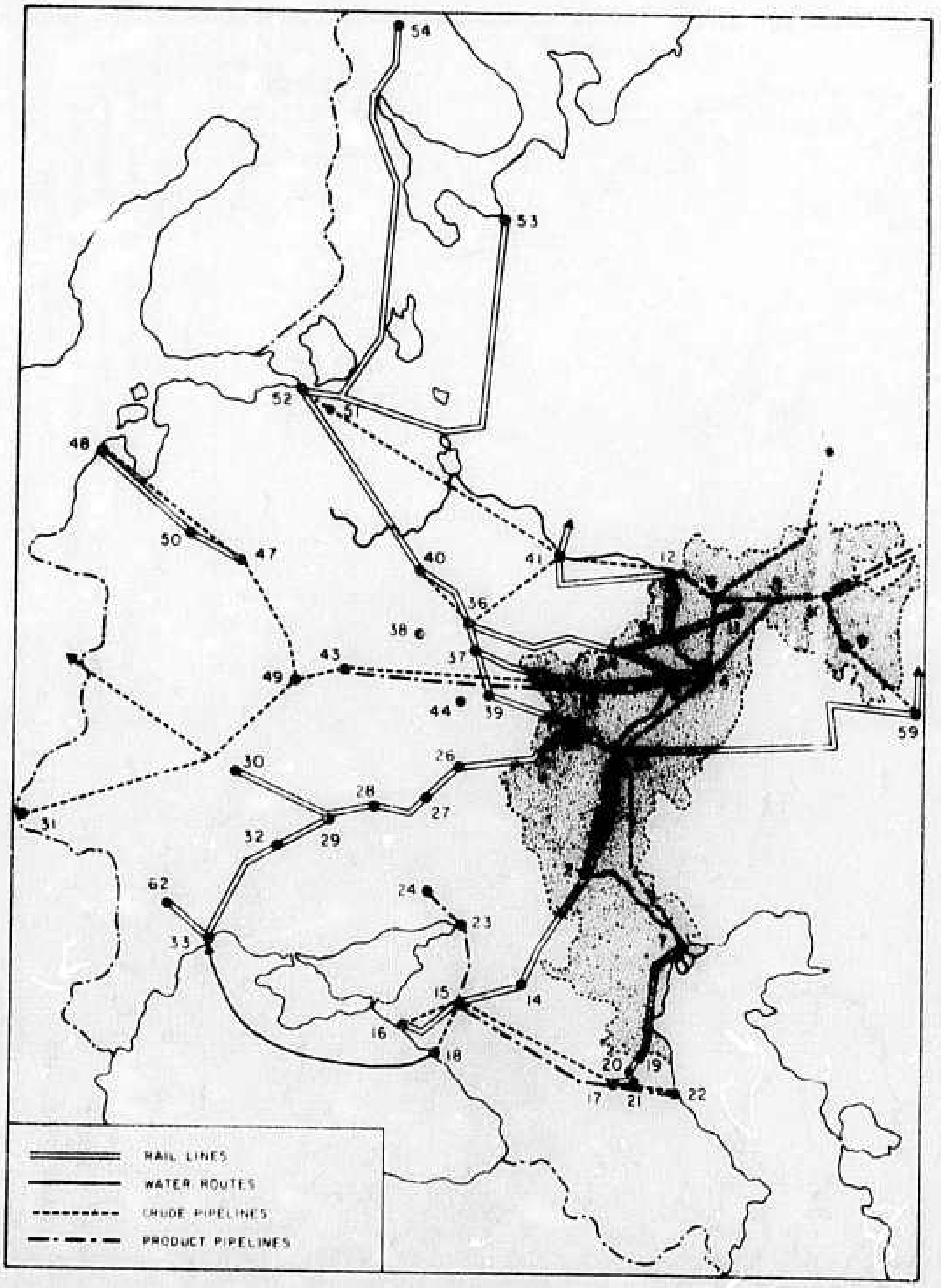

Figure C-3

VOLGA OIL TRANSPORT - WESTERN

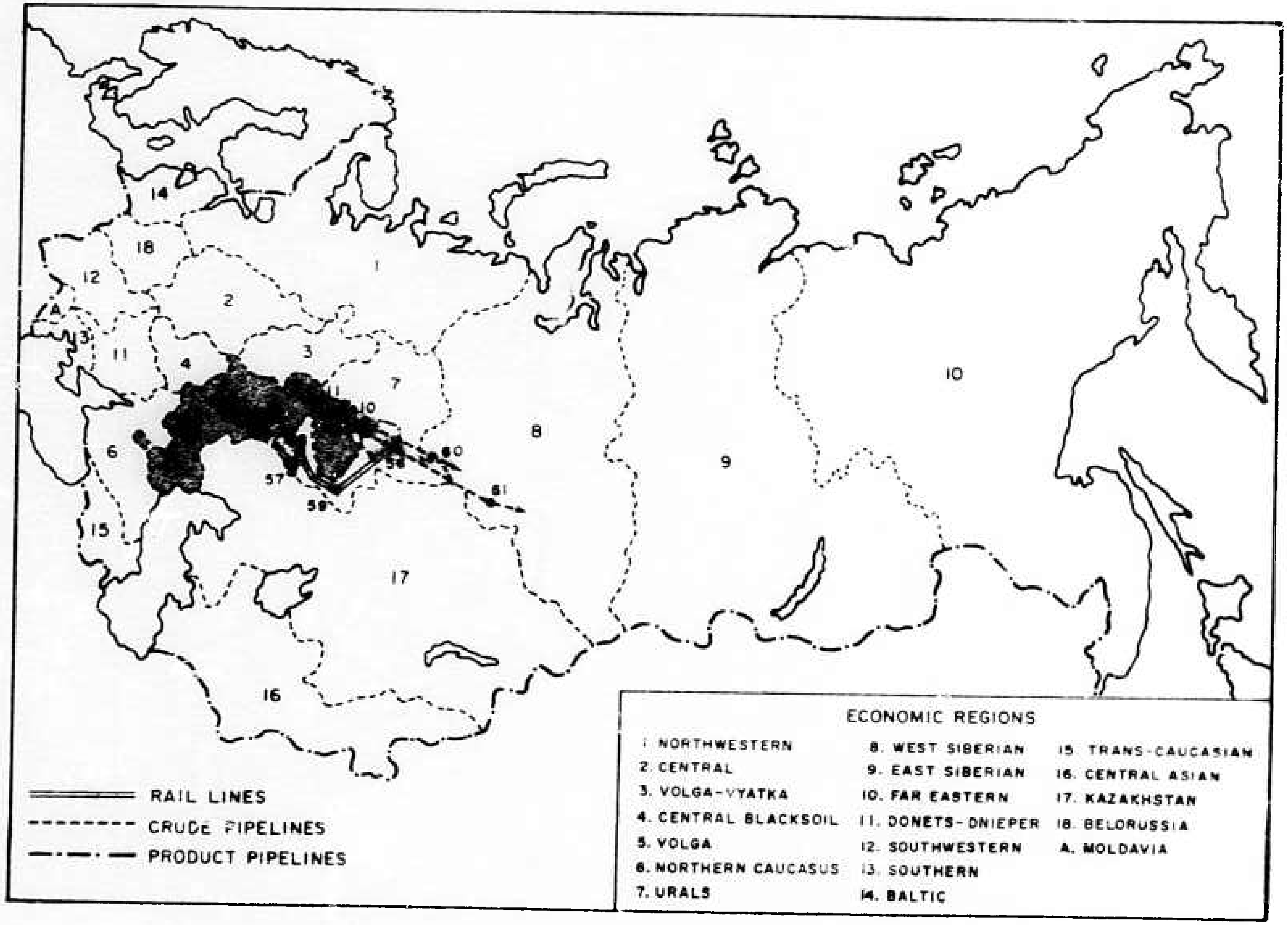

Figure C-4

VOLGA OIL TRANSPORT - EASTERN

vicinity of the oil storage and pipeline pumping station of Almetyevsk (6), which produced 101 million tons (707 million barrels) in 1970; the Bashkiria oil fields near the oil storage station of Tuimazy (5), which produced 41 million tons (287 million barrels) in 1970; and the Kuibyshev (4) fields, which produced 35 million tons (245 million barrels) in 1970. The crude oil from these regions is transported by rail, river tanker, and pipeline to nearby refineries within the Volga region, as well as to refineries in other economic regions of the country.

a. Oil Transport Within Volga Region

The principal oil refineries in the Volga economic region are located in Kuibyshev (4), Syzran (8), Ufa (10), Saratov (3), and Volgograd (2).

From Almetyevsk (6) in the Tatar Autonomous Russian Republic and Tuimazy (5) in the Bashkir Autonomous Russian Republic, crude oil is piped to the refineries of Ashimbay (9) (The diameter of all the existing oil pipelines in the Volga region is 1020 millimeters or 40 inches). Tuimazy crude oil is also piped to Kuibyshev, and some continues through the pipeline to refineries in Saratov. Finally, both Tuimazy and Almetyevsk crude oil are transmitted by pipeline to Ufa for refining.

Kuibyshev, Saratov, and Volgograd are major oil-drilling areas which also contain their own oil refineries. Some of the oil drilled in Kuibyshev, however, is sent by pipeline across the Volga River to Syzran's oil refineries and from Syzran via an oil product pipeline to Penza (13), an industrial city.

In addition to their role as oil-refining centers, the cities of Kuibyshev, Syzran, Ufa, Saratov and Volgograd are also principal railroad dispatch points, from which oil products are carried by rail to other regions of the country. Klyavlino (11) is also a major railway

dispatch center for oil products from Ashimbay and Ufa. The rail line from Kuibyshev to Syzran handles the largest oil-freight traffic (primarily oil products from Kuibyshev's refineries but some crude oil, too) of any rail line in the USSR.

Another major oil rail route follows the Volga rail line from Saratov to Volgograd, from where oil continues by rail into the Northern Caucasus region. In 1970 the total amount of Volga oil and oil products transported to industrial centers within the Volga by rail was 16.6 million tons.

Finally, oil products are shipped down the Volga River from Volgograd to Astrakhan (7), and millions of tons of oil products from refineries, and of crude oil from railroad depots are shipped from Volgograd, Saratov, Syzran, and Kuibyshev up the Volga toward the Volga-Vyatka economic region. The distances between dispatch points along the Volga are as follows: Volgograd to Saratov, 400 kilometers (km); Saratov to Syzran, 300 km, Syzran to Kuibyshev, 150 km, Kuibyshev to Kazan (12) (on the boundary between the Volga and Volga-Vyatka Economic Regions), 500 km. The total shipment of the Volga crude oil and oil products along the Volga River to industrial centers within the Volga region was 14 million tons in 1970.

The principal oil-using industrial cities in the Volga region are Volgograd, Saratov, Syzran, Kuibyshev, Ufa, and Penza. Astrakhan is also a principal industrial city, rail station, and sea and river port in the region. Astrakhan's industries include machine-production, food processing, shipbuilding, lumber processing, and cellulose production.

The uses of fuel oil in the Volga are as follows: 41.2 percent in electric power stations, 8.6 percent in industrial boilers, 15.6 percent on technological uses, 12.2 percent on transportation, and

22.4 percent on various other needs. About 55 percent of the oil products from the region are exported to other economic regions of the country.

b. Volga Oil Transport to Northern Caucasus Region

The main oil dispatch points from the Volga to the Northern Caucasus economic region are Volgograd (2) and Astrakhan (7).

From Volgograd crude oil and oil products are transported along the Northern Caucasus rail system to Salsk (14) and Tikhoretsk (15) (respective distances of 400 and 575 km), from which some of the oil-product cargo continues along the rail line another 300 km to **Novorossiysk** (16), and most of the crude oil is transported to **Novorossiysk** by pipeline.

Tikhoretsk (15) is a major oil refining center, with a machine-production and steel-finishing industry as well as food-processing plants. **Novorossiysk** is a large port and industrial city with heavy machinery, textile, food processing, and building-material (including cement) plants.

From Tikhoretsk crude oil is also piped 250 km to the large Black Sea port of Tuapse (18), which contains major oil-refining, chemical, and cement-producing plants.

From Astrakhan crude oil, shipped down the Volga River from the Volgograd-Saratov oil fields, is transported along the Caspian rail line of the Northern Caucasus system to Kizlyan (19), which is located 350 km south of Astrakhan by rail, Chervlennaya (20) 100 km. By rail from Kizlyan, and Gudermes (21), 40 km by rail from Chervlennaya. From Gudermes (21) the oil is then transported 40 km east by rail to the oil refineries of Groznyi (17).

Oil is also shipped from **Astrakhan's** Caspian sea port to Makhachkala (22), from where it is pumped 200 km to Groznyi's oil refineries.

In 1970, 15.4 million metric tons of Volga oil was transported along the Volgograd-Tikhoretsk and Astraklan-Gudermes rail lines to the Northern Caucasus economic region, and in the same year 2.8 million tons were shipped by ocean-tanker along the Caspian Sea Coast from Astrakhan to Makhachkala.

c. <u>Volga Oil Transport to Donets-Dnieper Region</u>

Oil products from the crude oil transported from the Volga region by rail to Tikhoretsk and Groznyi and by ocean tanker to Makhachkala are pumped through an oil-product pipeline stretching from these oil-refining cities to Rostov-na-Donu (23), a major coal-mining and industrial center 200 km from Tikhoretsk and 600 km from Groznyi. From Rostov, which is still in the Northern Caucasus although it is within the Donets coal basin-industrial complex, the pipeline continues to Trudovaya (24), located in the Donets-Dnieper region 250 km from Rostov. Trudovaya is in the middle of the central web of Donbass coal-storage and dispatch stations, from which oil products arriving in Trudovaya are transported by rail throughout the Donets-Dnieper region.

Volga oil is also shipped to the Donets-Dnieper region by rail from Saratov. Transported 200 km west to Rtishchevo (25), which is a major rail junction and a city for construction material and food processing, the oil is sent southwest along the Balashov rail line to Tiski (26), 350 km from Balashov; Valuiki (27), 175 km from Tiski; and Kharkov (28), 225 km from Valuiki. From Kharkov the oil is transported by rail throughout the Donets and Dnieper rail systems.

In 1970, 12.6 million metric tons of crude oil and oil products were imported by rail into the Donets-Dnieper region. The larger part of this oil came from another region (the Northern Caucasian oil fields, which will be discussed later in this section), but several

million tons consisted of Volga oil transported from Saratov to Rtishchevo and then along the Balashov rail line to Kharkov.

d. Volga Oil Transport to Southwestern, Southern and Moldavian Regions

The several million tons of Volga oil products transported by rail from Saratov along the Balashov line to the Donets-Dnieper region represent only part of the Volga oil freight carried along this line. Most of the oil-products arriving in Kharkov via this rail route continue west to the Southwestern economic region, and south to the Southern and Moldavian economic regions.

Unlike coal, most of which is transported along a few clearly defined main rail lines, the oil rail transport system fans out onto dozens of major and auxilliary rail lines in each of the reciprocal economic regions of the country. And whereas the arrival stations for coal consist of three or four major rail stations, the arrival stations for oil again number in the dozens for most of the regions of the USSR. Therefore, it is not feasible or useful to identify every rail route and railroad arrival station for oil in each region.

The largest amount of Volga oil transported by rail into the Southwestern region is carried along the Dnieper rail line from Kharkov (28) to Poltava (29), located 225 km from Kharkov and 1,000 km from the Volga dispatch station of Saratov; and Kiev (30), located 325 km from Poltava in the Southwestern economic region. In 1970, 11.4 million metric tons of crude oil and oil products were imported into the Southwestern region, and most of this was from the Volga oil fields. (The rest was from the Northern Caucasian fields, which will be discussed later.)

Some crude oil from the Kuibyshev oil-fields was also piped into the Southwestern region through the Druzhba ("Friendship")

pipeline, which runs through the northwestern part of the region through the oil-processing city of Uzhgorod (31) on its way to Czechoslovakia and the other COMECON countries of Eastern Europe. The distance of this 40-inch diameter pipeline between Kuibyshev and Uzhgorod is 2,100 km.

The largest volume of Volga oil-products transported into the Southern region by rail are carried along the Kharkov-Poltava-Znamenka line, which intersects the Dnieper and Donets rail systems at Poltava (29) and Znamenka (32), and continues along the Southern rail system primarily along the Znamenka(32)-Odessa(33) rail line. Odessa, the largest Soviet seaport for foreign shipping and a major industrial city, is located 700 km south of Kharkov (28) by rail and 1,475 km by rail from the Volga region dispatch station of Saratov. Odessa also receives Volga oil products from refineries in Tuapse via ocean tanker. The distance from Tuapse to Odessa is 1,370 km. The total distance from Volgograd (2) by rail to Tikhoretsk, by pipeline to Tuapse, and from Tuapse by tanker to Odessa is 1,930 km.

From Odessa (33), Volga oil is transported 300 km north along the Odessa-Kishinev rail line to Kishinev (62) in Moldavia. Like Odessa, Kishinev is a major industrial city.

In 1970, 17.8 million metric tons of crude oil and oil products were imported from the Volga (and Northern Caucasus) economic regions into the Southern region by rail, and the larger part of this was from the Volga region. In the same year, 2.4 million tons were imported by rail into Moldavia from Odessa.

e. Volga Oil Transport to Central Economic Region

The greatest volume of rail-transported oil products in the USSR runs along the Kuibyshev rail line from Kuibyshev (4) to Syzran (8).

More than half of the oil products sent by rail from Kuibyshev to Syrzan continue by rail to Penza. The remainder of the oil products in Syrzan is transported 200 km by rail to Inza (34), where it merges with a rail shipment of oil from Ulyanovsk (35). located 150 km to the east of Inza. The oil from Ulyanovsk is primarily Bashkir and Tatar oil transported by rail from the Volga oil storage station Klyavlino (11), 300 km west to Ulyanovsk (35).

Ulyanovsk is a large industrial center, with plants producing transport machinery, and heavy machinery; other plants include lumber and food processing, and metal finishing plants. Inza is also a large industrial city containing chemical plants, lumber plants, and construction-material plants.

From Inza, oil continues by rail 500 km to Ryazan (36), an industrial city and rail junction in the Central economic region.

In Ryazan the oil from Inza is joined by oil transported 250 km by rail from Michurinsk (39).

The oil from Michurinsk originates in Saratov, from which it is transported 450 km to Michurinsk and then up the Michurinsk rail line to Ryazan and Moscow (40).

In addition to the rail shipments from Inza and Saratov, some of the oil products sent to Penza (13) continue along the Penza-Ryhask (37) line of the Central rail system from Penza to Tula (38)--a distance of 650 km.

The total rail import of oil products into the Central region in 1970 was 11.8 million tons, most of which came from the Volga oil fields. In addition, in the same year, another 4.4 million tons of oil products from Kuibyshev and other Volga refineries was shipped up the Volga River through the Volga-Vyatka region and into the Central region.

As mentioned earlier, the oil arriving by rail into a given region fans out onto all of the major and most of the auxilliary rail lines for distribution to every point of oil-need in the region, and this is certainly true of the Central region. The uses of fuel oil in this region are as follows: 9.0 percent for electric power stations, 28.2 percent for industrial boilers, 13.4 percent for technological needs, 28.7 percent for transportation, and the remainder for various other needs. The large percentage of the fuel oil used in transportation reflects the relatively intensive development of hand-surfaced roads and of automobile and truck transport present in the Central region.

Volga oil is transported to the Central region primarily by pipeline. A double-string, 40 inch diameter, crude oil pipeline stretches 600 km from Almetyevsk to Gorkii (41), from which one pipeline continues on to Yaroslavl (42), a distance of 400 km, and another runs to Ryazan, a distance of 375 km from Gorkii (41). Yaroslavl and Gorkii contain oil refineries. From Ryazan, some of the crude oil continues on to Moscow, through a 40-inch pipeline. The length of the Ryazan-Moscow crude oil pipeline is 175 km.

Running parallel to the Druzhba or Friendship pipeline (which transmits crude oil from Kuibyshev to the COMECON countries of Eastern Europe as well as to Belorussia and the Baltic region) is a 40-inch oil-product pipeline running through Penza and continuing on to Bryansk (43) in the Central economic region, from which it is distributed by truck and rail to various oil-demanding points within the region. Bryansk itself is a large industrial city with transport machinery, metal-processing, and heavy machinery plants as well as a thermal electric power station.

The relative costs of imported fuel oil and various types of domestic and imported coals in terms of conventional fuel (that is,

in terms of the cost of the equivalent amount of coal needed to produce 7,000 kilocalories) are shown in Table C-23.

Table C-23

RELATIVE COSTS OF FUEL OIL AND COAL IN TERMS OF COAL EQUIVALENT*
(Rubles per Ton)

Point of Fuel Demand	Fuel Oil	Donbass Coal†	Moscow Coal‡	Kuzbass Coal‡
Moscow	2.1	9.3	12.4	7.6
Tula	2.8	9.1	11.9	-
Ivanovo	2.9	9.2	-	7.6
Bryansk	3.0	8.8	-	-
Kaluga	2.8	9.2	12.4	8.0
Ryazan	2.0	8.9	12.2	-
Smolensk	2.8	9.2	-	-
Yaroslavl	2.7	9.5	-	7.5

* Cost of the equivalent amount of coal needed to produce 7,000 kilocalories.

† Underground mined.

‡ Surface mined.

f. Volga Oil Transport to Central Blacksoil and Volga-Vyatka Regions

The main transport mode for transmitting Volga oil to the Central Blacksoil region is the oil-product pipeline stretching from Kuibyshev to Penza and from Penza to the Central Blacksoil industrial city of Lipetsk (44), which was described in an earlier section. The distance of the 40 inch diameter pipeline between Penza and Lipetsk is 400 km.

In 1970, 6 million tons of oil products were transported into the Central Blacksoil region by rail, principally from Saratov, along the Saratov-Rtishchev and Balashov rail lines to the rail junction of Liski (26), from where oil was distributed throughout the Central Blacksoil region by rail. The rail distance from Saratov to Liski is 600 km.

The principal mode of oil transport to the Volga-Vyatka region also is the pipeline. From the Almetyevsk (6) storage and pumping station, crude oil is piped through two 40 inch diameter pipelines to Gorkii (41), which has a large oil refining industry as well as other industries which were described in an earlier section. The distance of the pipeline between Almetyevsk and Gorkii is 600 km.

In 1970, 2.4 million tons of oil products were shipped up the Volga to Kazan, a Volga-Vyatka riverport described in an earlier section. In the same year 3.8 million tons of oil products were transported by rail from the oil storage and railroad dispatch station of Klyavlino to Ulyanovsk (35) and then up the Volga rail line to Kazan and the lines of the Gorkii rail system in the Volga-Vyatka region. The distance by rail from Klyavlino through Ulyanovsk to Kazan is 700 km.

g. Volga Oil Transport to Belorussia, Baltic states, and Northwestern Region

The Druzhba crude oil pipeline from Kuibyshev and Penza to Bryansk (43) and the COMECON countries has a tributary pipeline stretching 1,000 km from Unecha (49) to Polotsk (47) in Belorussia and on the the Latvian seaport of Ventspils (48). The distance of the 40-inch pipeline from Kuibyshev to Unecha (49) is 1,200 km, from Unecha to Polotsk, 400 km, and from Polotsk to Ventspils, 600 km.

Polotsk contains oil refineries as well as chemical plants, including petrochemical plants, and processed oil from Polotsk is

currently transported by rail to Daugavplis (50) in Latvia, which has machinery and building-material plants as well as a food-processing and lumber industry. From Daugavplis it is transported along the Baltic rail system to points of demand within the Baltic economic region. The total railroad import of oil products into the Baltic region in 1970 was 21.1 million metric tons. At present, an oil-product pipeline is being constructed between Polotsk and Ventspils and should relieve the oil load from the railroads when completed.

The crude oil pipeline running from Polotsk to Ventspils transmits crude oil for export along the Baltic shipping routes to other nations. There are no refineries in the Baltic region itself.

The 40-inch pipeline carrying crude oil from Almetyevsk (6) to Gorkii and from Gorkii to Varoslavl (42) continues on to the oil refineries of Kirishi (51), from which processed oil continues by pipeline 150 km to Leningrad (52). The total length of the pipeline-route from Almetyevsk to Kirishi is 1,350 km.

O: . products from Volga crude are also sent to Leningrad (52), Arkhangelsk (53), and Murmansk (54) by rail along the October line from Moscow. In 1970, 8.5 million metric tons of oil products were shipped up the October rail line from Moscow, which in turn received its crude oil, from which the oil products were derived, by pipeline from the Volga oil fields.

h. Volga Oil Transport to Urals

The Volga and Urals economic regions constitute a single oil production region, and some crude oil from each of the two regions is sent to the other region's refineries.

Crude oil from Almetyevsk is sent through the 40-inch Almetyevsk-Perm pipeline to the oil refineries of Perm in the Urals.

Some of the crude oil sent from Almetyevsk via pipeline to Ufa's refineries continues through the 40-inch pipeline to Chelyabinsk (56) in the Urals for refining.

Some crude oil is also transported to Chelyabinsk by railroad via the Southern Ural rail system from Saratovo to Iletsk (57), Orenburg (58), Orsk (59) (which has its own refineries), and Chelyabinsk (56). The distance traveled by rail-transported oil from Saratov to Orsk is 1,300 km, and from Orsk to Chelyabinsk, 500 km. Another oil-carrying rail line runs from Kuibyshev to Ufa, from which some oil continues by rail to Chelyabinsk. The rail distance from Ufa to Chelyabinsk is 400 km.

In 1970, 8.9 million metric tons of Volga crude oil was transported by rail into the Urals economic region. Although pipelines have replaced railroads to a large extent in the transport of crude oil in the Volga-Urals oil region, railroads still provide an auxilliary form of transport.

There are currently two product pipelines running between Ufa (10) in the Volga region and Chelyabinsk (56) in the Urals region, and a fifth pipeline (for crude oil) is under construction between the two oil refining and oil dispatch cities.

i. Volga Oil Transport to Western Siberia

In 1970 several pipelines, which were built in the 1960s for the transmission of crude oil from the Volga-Urals fields to Western and Eastern Siberia, began to be used for reverse flows: from the newly tapped oil fields of Western Siberia to the industrial regions of the Urals and the Volga.

Thus, the Almetyevsk-Ufa-Kurgan (60) 40-inch pipeline, carrying crude oil from Almetyevsk to Kurgan (a distance of 850 km.)

began to transport oil in 1970 from West Siberian fields to Ufa. Similarly, the 40-inch 125 km Tuimazy-Ufa-Omsk (51) pipeline and the 1,150 km Ufa-Omsk pipeline had the directions of their oil flows reversed from east to west.

3. Urals Oil Transport

Figure C-5 presents the map to which the following discussion is keyed by number.

In 1970 about 25 million metric tons of crude oil was produced in the Urals economic region. The three main oil fields in the Urals are located at Perm (1), which produced 16 million tons in 1970; western Orenburg Province (4), which produced about 8 million tons the same year; and Udmurtia (3), which produced about a million tons.

The western Orenburg fields are really an eastward extension of the Kuibyshev fields, and the crude oil from the western part of Orenburg Province is shipped no more than 150 km by the 350 km Orenburg-Kuibyshev (5) rail lines or by the 40-inch Bavly (6) -Krotovka (7) -Kuibyshev pipeline to Kuibyshev. Kuibyshev is, in turn, the main refining center and dispatch station for eastern Orenburg crude and oil products to other regions.

The oil from the recently tapped Udmurtia fields (3) is refined both in the refineries of Krasnokamsk (8), to which it is transmitted by rail and truck over distances of no more than 50 km, and Perm, which also receives crude by rail and truck and by 40-inch pipeline from the local Perm fields. Perm, Krasnokamsk, and Kuibyshev, all of which have rail stations, riverports, and pipeline pumping stations, are the three dispatch points for Ural oil.

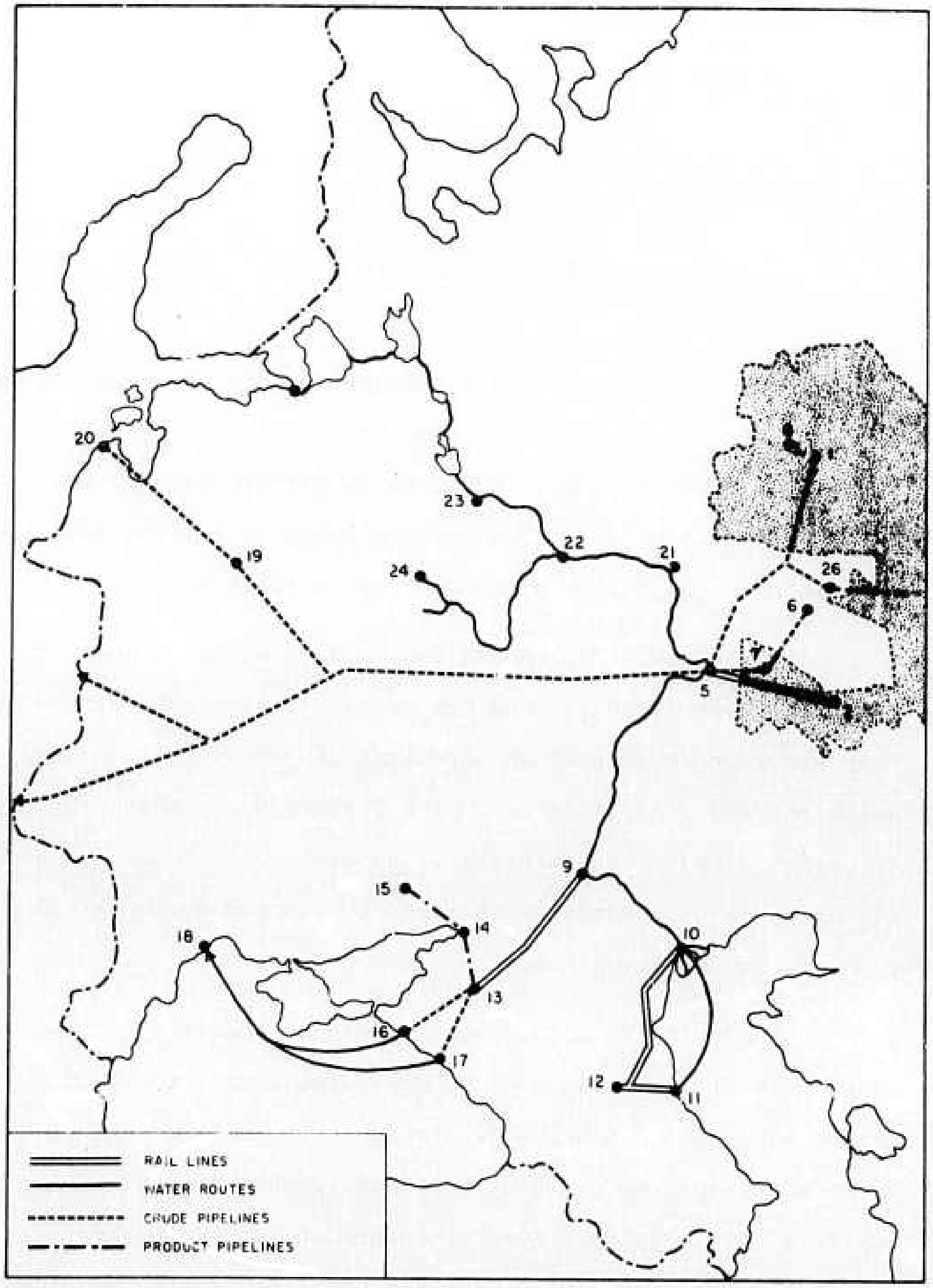

Figure C - 5

URALS OIL TRANSPORT

a. <u>Urals Oil Transport to Volga, Northern Caucasus, Donets-Dnieper, and Southern Regions</u>

Most of the Ural crude going to these regions is transmitted through Kuibyshev, the Volga city and chief arrival point for west Orenburg oil. From Kuibyshev, tankers and barges of crude are sent down the Volga 800 km to Volgograd (9), from which some continues 450 km along the Volga to the Caspian seaport of Astrakhan (10), where it is dispatched 250 miles by ocean tanker to the North Caucasian port of Makhachkala (11), and thence by rail from Makhachkala to the refineries of Groznyi (12), 200 km by rail from Makhachkala. Some of the crude arriving in Astrakhan is sent by rail to Groznyi along the Caspian line of the Northern Caucasus rail system--a distance of 550 km.

From Volgograd, Ural crude is also sent along the Volgograd-Tikhoretsk line of the Northern Caucasus rail system to Tikhoretsk (13), located 500 km by rail from Volgograd; and from Tikhoretsk, which contains an oil-refining industry. Some oil products are piped 200 km to Rostov (14) and some, the full 450 km length of the pipeline to Trudovaya (15), which lies in the middle of the Donbass in the Donets-Dnieper region.

Some of the crude in Tikhoretsk is pumped 250 km to Novorossivsk (16), one of the largest seaports for the foreign export of oil in the USSR. Some is pumped through the 275 km pipeline from Tikhoretsk to Tuapse (17), from which crude and oil products produced in the refineries of Tuapse are shipped by ocean tanker 550 miles to Odessa (18), in the Southern economic region.

b. <u>Urals Oil Transport to Belorussia and Baltic Region</u>

Some of the Urals crude from the Orenburg fields is transmitted from Kuibyshev through the Druzhba pipeline to Polotsk (19) in Belorussia for refining, and then the products proceed to the Baltic

export port of Ventspils (20)--respective pipeline distances of 1,600 and 500 km.

c. Urals Oil Transport to Volga-Vyatka, Central, and Northwestern Regions

Some of the oil products produced in Kuibyshev's refineries from the Urals crude are shipped up the Volga to Kazan (21) (located 400 km from Kuibyshev) and Gorkii (22), located 375 km from Kazan, from which some of the refined oil continues 375 km along the Volga to Yaroslavl (23) in the Central region and some continues along the Oka River system to Moscow (24)--a river distance of 650 km.

From Yaroslavl, oil products continue along the northern inland river-canal system to Leningrad (25)--a distance of 900 km from Yaroslavl.

d. Urals Oil Transport to Western Siberia

Prior to 1970 crude oil from the Perm fields was pumped through a 40-inch pipeline link from Perm to Ufa (26) (375 km) and then through the Ufa-Omsk crude and product pipelines (1,150 km) to Omsk in Western Siberia. Since 1970, however, with the rising exploitation of the West Siberian oil fields, the flow through the Ufa-Omsk pipes has been reversed, with West Siberian crude and oil products now flowing into the refineries of Ufa and some continuing north via pipeline to Perm's refineries.

e. Urals Oil Transport Within Urals Region

Whereas all of the 8 million tons of western Orenburg crude produced in 1970 was sent out of the region to Kuibyshev for refining and dispatch to various other regions, virtually all of the 16-17 million tons of oil from the Perm and Udmurtia fields was processed and

distributed within the Urals. Perm itself used much of the refined oil produced from local crude, and between 8 and 9 million tons of refined were distributed to other points in the Urals along the Urals rail system.

4. Northern Caucasus Oil Transport

Figure C-6 presents the map for oil transport relating to the Northern Caucasus.

In 1970 34.5 million metric tons of oil were produced in the four oil fields of the Northern Caucasus economic region. The four fields are located at Makhachkala (1) (the Daghestan fields), Groznyi (2) (the Chechen-Ingush fields), Stavropol (3), and Krasnodar (4). The main oil refineries are situated in Tuapse (5), Krasnodar, Groznyi, and Makhachkala. A series of small pipelines connect the wells of the Krasnodar field to the refineries at Krasnodar and Tuapse (5); the wells of Groznyi field to the refineries in Groznyi (2), and the wells of Makhachkala to each other.

In addition, a 155 km pipeline carries some of the Makhachkala crude to Groznyi for refining, and some of the Groznyi crude is transported through the 800 km Groznyi-Tikhoretsk (30) -Tuapse pipeline to Tuapse for refining. Finally, crude oil from Stavropol is transported along the Stavropol-Kropotkin (6) -Krasnodar rail line to refineries in Krasnodar, which is a total rail distance of 300 km.

The volume of crude produced in each of the oil fields in the Northern Caucasus in 1970 was as follows: Makhachkala, 2 million tons; Groznyi, 20.5 million tons; Stavropol, 6.5 million tons; and Krasnodar, 5.5 million tons.

Oil products from Groznyi, the largest oil field and refinery center in the region are piped through the Groznyi-Tikhoretsk-Rostov (10)-

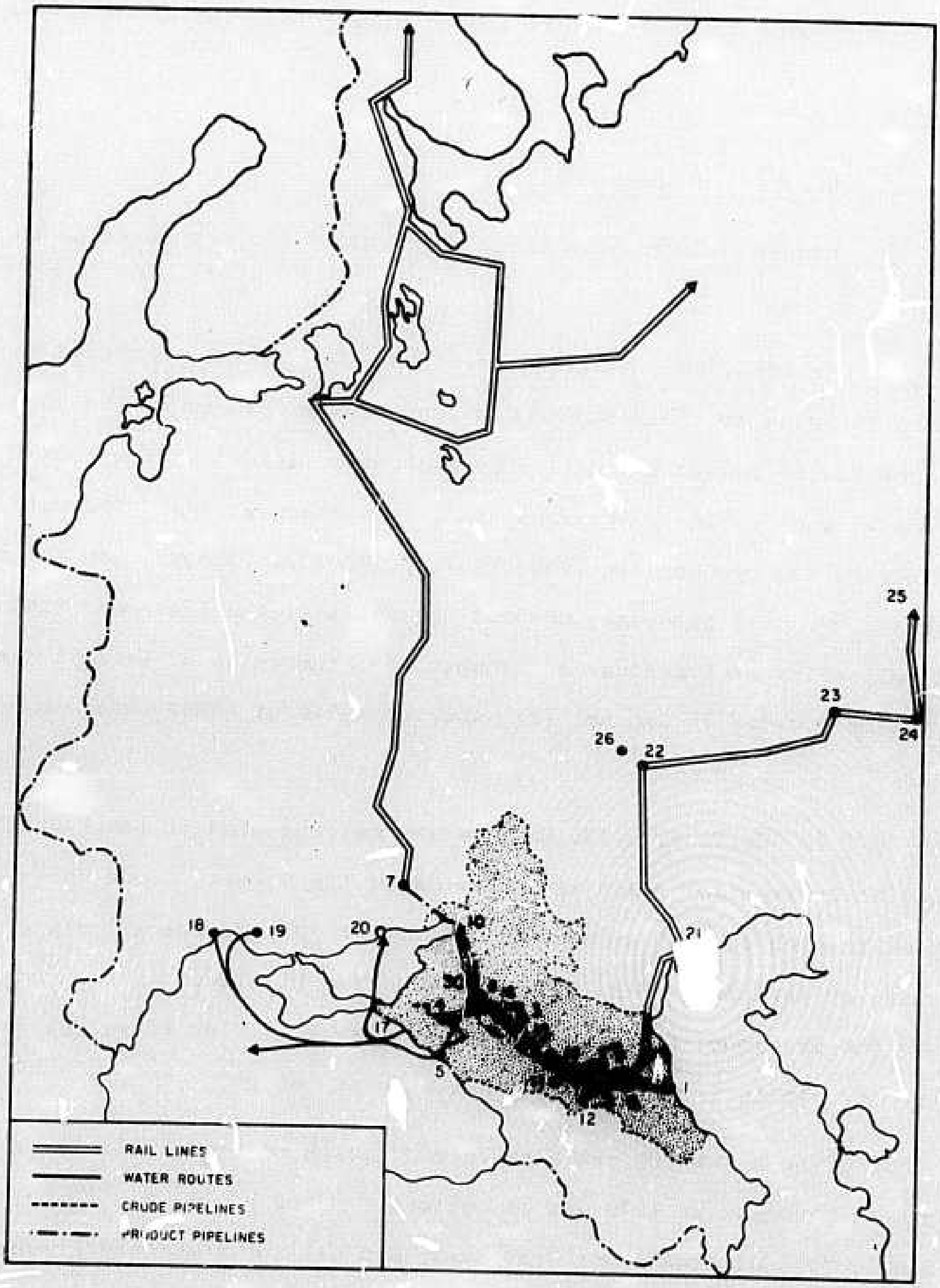

Figure C-6

NORTHERN CAUCASUS OIL TRANSPORT

Trudovaya (7) product pipeline 900 km to Trudovaya in the Donets-Dnieper region.

The rest of the oil products produced in the region are carried predominantly by rail and by ocean tanker. The greatest oil freight, storage, and dispatch rail stations in the region are located at Groznyi, Gudermes (8), and Chervlennaya (9). Between Gudermes and Chervlennaya is some of the heaviest oil freight railroad traffic in the USSR. In 1970 a total of 33.5 million tons of crude and oil products were dispatched by rail in the Northern Caucasus, and most of this freight was handled by the stretch of track between Gudermes and Chervlennaya.

The proportion of fuel oil to other types of energy fuel in the USSR is as follows: fuel oil, 32 percent; gas, 35 percent; coal, 28 percent; other types of fuel, 5 percent. The uses of fuel oil are divided among the following: electric power stations, 8.4 percent; industrial boilers, 10.4 percent; technological needs, 14.9 percent; transportation, 34.4 percent; various domestic needs, 31.9 percent. The comparative use of fuel oil to other forms of fuel in electric power stations in various parts of the region is as follows:

	Coal	Gas	Fuel Oil	Other Fuels
Northern Caucasus in general	26.2%	60.8%	8.4%	4.6%
Rostov (10)	82.2	7.2	7.5	3.1
Krasnodar (4)	0.4	86.8	5.6	7.2
Stavropol (3)	-	93.5	1.1	5.4
Groznyi (2)	15.2	7.3	10.2	1.1

The comparative costs of Northern Caucasus fuel oil to gas and coal at various points of fuel demand in the Caucasus are presented in Table C-24.

Table C-24

COSTS OF NORTHERN CAUCASUS FUEL OIL
COMPARED TO COSTS OF COAL AND GAS
(Rubles per Ton of Conventional Fuel)

Point of Demand	Local Fuel Oil	Donbass Coal	Local Gas
Rostov	3.5	7.9	0.9
Krasnodar	2.7	8.2	0.7
Stavropol	3.7	8.5	1.0
Nalchik	3.5	8.8	-
Ordshonikidse	3.4	8.8	1.7
Groznyi	2.7	8.9	1.5
Makhachkala	3.4	9.1	-

Source: A. Probst, Razvitie toplivnoi bazy raionov SSR

a. Rail Transport of Northern Caucasus Oil Products within the Northern Caucasus Region

The main rail line for oil products begins at Makhachkala and runs along the Northern Caucasus rail system to Gudermes (8), a distance of 150 km. Gudermes also receives oil products from Groznyi (2), which is located 50 km to the west. From Gudermes, oil freight is transported 40 km to Chervlennaya (9), from which some is transported up the Caspian line of the Northern Caucasus rail system to Kizlyar (13), 115 km from Chervlennaya, and then toward the Volga economic region.

Most of the oil freight leaving Chervlennaya (9) is transported west to Prokladnaya (14), 200 km from Chervlennaya. Prokladnaya is a small railroad junction city with a food-processing plant and a building-material factory. Prokladnaya also receives oil freight from Groznyi. Some of the westward-bound oil freight from Groznyi is

dispatched to Ordzhonikidze (12), a large metal-finishing and nonferrous metallurgical city which also contains food-processing and building-material plants and a hydroelectric station. Ordzhonikidze (12) is located 150 km by rail from Groznyi. Just before arriving in Prokladnaya, some of the Groznyi oil products are sent along a 60 km auxilliary rail line to the city of Nalchik (11), which has a machinery and metal-finishing industry and a food-processing plant. The total direct rail distance from Groznyi to Prokladnaya is 300 km.

From Prokladnaya the main rail route for oil cargo continues along the Northern Caucasian line to Nevinnomysskaya (15), a large industrial city 300 km by rail from Prokladnaya, with chemical, cement, food-processing, lumber, machinery, and metal-finishing plants plus a thermal electric power station.

The rail line continues in a northwesterly direction to Armavir (16) (350 km from Prokladnaya), a machinery and metal-finishing city with lumber and food-processing plants.

From Armavir (16), the line continues to Kropotkin (6), where it is intersected by the Stavropol-Kropotkin-Krasnodar rail line carrying crude oil from the Stavropol oil fields (3) to the refineries of Krasnodar. Continuing along the main Northern Caucasian rail line, the Prokladnaya oil product shipment is carried to Rostov (10) and the coal mining and iron and steel making industrial complex of the Donets Basin. The distance by rail from Prokladnaya to Rostov is 750 km.

b. Northern Caucasus Oil Transport to Donets-Dnieper and Southern Regions

In addition to the rail line discussed in part a. of this section, the Groznyi-Tikhoretsk-Rostov-Trudovaya product pipeline also carries Northern Caucasian oil products into the Donets-Dnieper region.

From the Donbass, Northern Caucasus oil products are then distributed throughout the Donets-Dnieper, Central Blacksoil, Central, and Northwestern regions by the main and auxiliary lines of the Kursk, Moscow, October, and Northern rail systems. Most of the 16.1 million tons of oil products exported by rail from the Northern Caucasus region in 1970 were transported to the rail lines enumerated above.

Large quantities of oil products were also shipped by ocean tanker from Tuapse (5) and Novorossiysk (17) to foreign ports as well as to the Southern region's ports of Odessa (18) (850 miles), Kherson (19) (850 miles), and Berdyansk (20) (500 miles). In 1970, 3.7 million tons of Northern Caucasus oil products were shipped by ocean tanker from Tuapse and Novorossiysk to the Southern economic region.

c. Northern Caucasus Oil Transport to Volga and Ural Regions

Oil products dispatched northward from Chervlennaya (9) along the Caspian line of the Northern Caucasian rail system continue on to Astrakhan (21)--a distance of 500 km by rail. Some of the oil cargo continues north to Pushkino (22), 600 km from Astrakhan, where it merges with eastward-bound oil products dispatched from Saratov (26).

The oil product cargo then continues east to Iletsk (22), Orenburg (23), Orsk (24), and Chelyabinsk (25). The volume of this shipment is very low.

5. Western Siberia Oil Transport

Figure C-7 presents the map for oil transport relating to Western Siberia.

Oil was first tapped in the Western Siberia fields in 1960, and by 1970 eleven fields in the region were producing 31.5 million tons of crude oil annually. The main oil fields of Western Siberia are

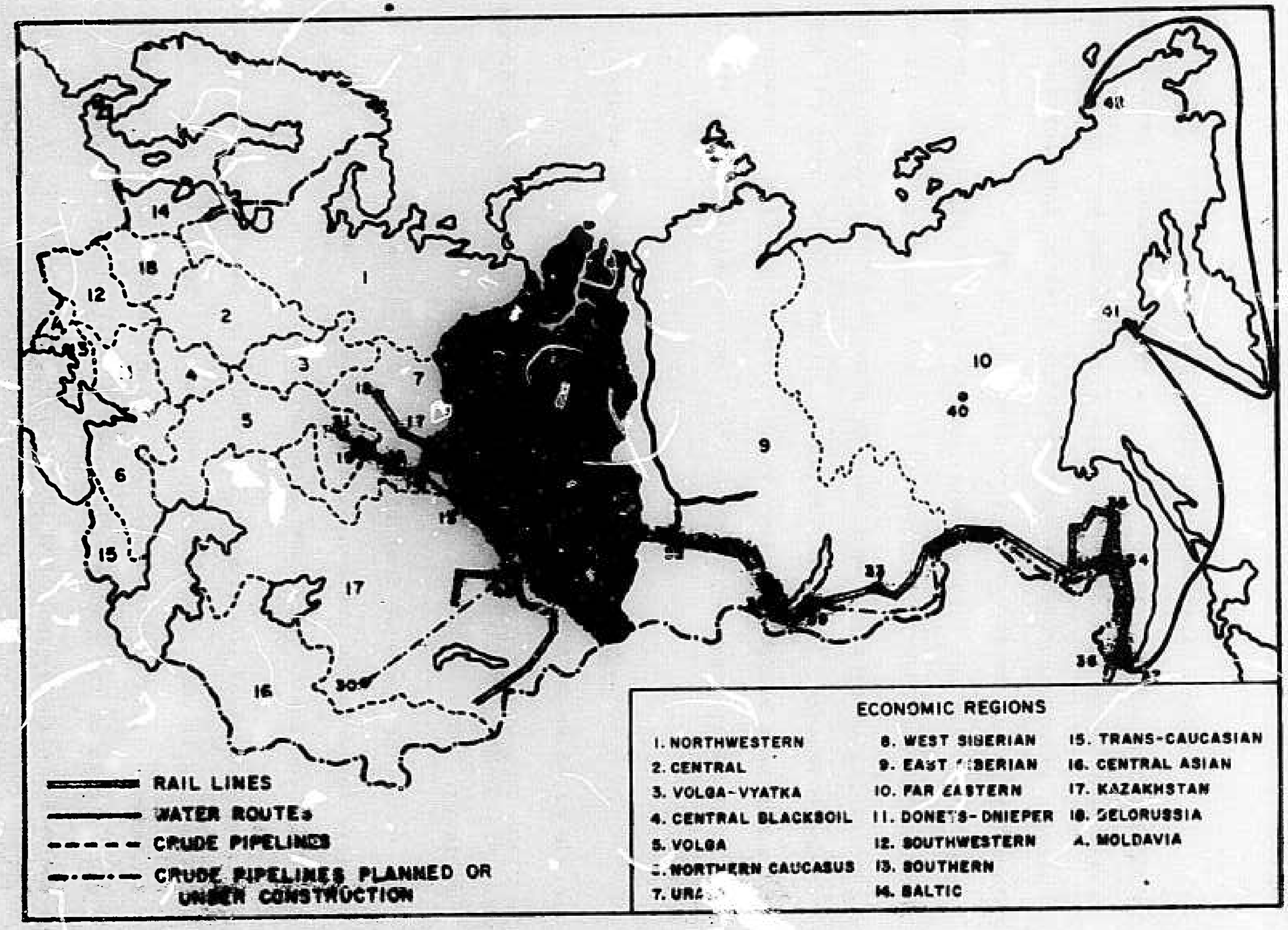

Figure C-7

WESTERN SIBERIA OIL TRANSPORT

located near Shaim (1), Surgut (2), along the Middle Ob River (3), and near Novosibirsk (4). The oil refining centers of Western Siberia are located at Tyumen (5), Omsk (6), Novosibirsk and Aleksandrovskaye (8).

Western Siberia is currently the scene of the greatest pipeline construction activity in the USSR. In 1970, a 48-inch pipeline carried crude from wells in Aleksandrovskaye along the 250 km pipe route to Surgut. Passing through several developed fields, the Aleksandrovskaye-Surgut pipeline is fed crude from these fields at various pumping stations along the way. Crude continues through the pipeline from Surgut to Tobolsk and Omsk (a distance of 725 km), where most of it is refined. Some of it, however, is sent through pipelines for refining in other economic regions. In 1970, nearly 3 million tons of crude oil and oil products were shipped by river tanker down the Ob from Aleksandrovskaye to Tomsk (10), Anzhero-Sudzhensk (12), and Novosibirsk, all within Western Siberia.

Oil from Shaim's fields is pumped through the 48-inch, 375 km crude pipeline to the refineries of Tyumen.

Oil from the Novosibirsk fields is refined in the Novosibirsk refinery.

The costs of fuel oil compared to costs of other types of energy fuels in the Western Siberia industrial complex (in the vicinity of Omsk and the Kuzbass) are given in Table C-25.

Much of the crude oil produced in Western Siberia is sent to refineries in other regions, whereas most of the oil products produced in Western Siberia refineries is used in the Kuzbass and Omsk metallurgical centers of the greater Urals-Kuznets metallurgical complex. Most of the oil freight to and from this region is transmitted by 48-inch pipeline. However, in 1970, 10.2 million tons of Western Siberia crude and oil products were transported to other regions by rail. About 200,000 tons were shipped by river tanker.

Table C-25

COSTS OF WESTERN SIBERIA FUEL OIL COMPARED TO
COSTS OF COAL IN OMSK AND KUZBASS AREAS
(Rubles per Ton of Conventional Fuel)

	Coal			Fuel Oil	
Point of Demand	Kuzbass	Kansko-Achinsk	Ekibastuz	Omsk/ Novosibirsk	Tyumen
Omsk	4.1	-	3.0	2.8	-
Novosibirsk	3.4	3.0	-	4.0	-
Kemerovo	2.7	2.8	-	4.3	-
Tomsk	3.1	3.0	-	4.3	-
Barnaul	3.3	-	2.6	5.0	-
Tyumen	4.9	-	3.9	-	4.0

a. Western Siberia Oil Transport to Urals and Volga Regions

Some of the crude and petroleum products leaving Western Siberia by rail moves west along the Chelyabinsk and Sverdlovsk lines. Oil is transported from Omsk (6) to Petropavlovsk (13), 300 km; Kurgan (14), 225 km; and Chelyabinsk (15), 250 km; and from Omsk to Vagay (16), 450 km; Sverdlovsk (17), 425 km; and Perm (18), 300 km. From Chelyabinsk, Sverdlovsk, and Perm, the oil is distributed to other points in the Urals and Volga regions via pipelines and the Urals and Kuibyshev rail systems.

Two crude oil pipelines and one product pipeline (all 3 of which have 48-inch diameters) connect Omsk to Petropavlovsk; and from Petropavlovsk, two crude and two product pipelines continue to pump Western Siberia oil to Ufa (19), 1,100 km from Omsk, where it is sent through the Urals-Volga pipeline system (see Volga Oil Transport section) to the European regions of the country.

At present a new 48-inch direct pipeline connection from Ustbalyk (20) in the Middle Ob fields to Tobolsk (9), Kurgan (14), and Ufa is under construction. When finished, the length of the pipeline will be 2,125 km. Through this line, Central Ob oil will be able to be piped directly to the Urals without being routed, as it is now, through Omsk.

A 48-inch, 200 km pipeline is also being constructed between Tyumen, where crude from the Shaim fields is now being refined to Kurgan. This will be a crude oil pipeline which will connect up with the westward bound Ural and Volga oil flows in the Kurgan-Ufa pipelines. Tyumen refined oil is currently being transported by rail 300 km to Sverdlovsk (17).

b. Western Siberia Oil Transport to Kazakhstan

In 1970, 7 million tons of oil products were transported by rail into Kazakhstan from Omsk, principally along the Omsk-Pavlodar

line (625 km), and about 150,000 tons were transported between the two cities by Irtysh River tanker.

A 48-inch pipeline is currently under construction between Omsk and Pavlodar (48) and between Pavlodar and Chimkent (30). An oil refinery is being built in Pavlodar. Chimkent already has an oil refinery, construction of which was finished in 1972.

When the pipeline from Omsk to Chimkent is complete, the crude oil imported from Omsk by pipeline into Kazakhstan will increase substantially, and the railroad traffic will be eased.

c. <u>Western Siberia Oil Transport to Eastern Siberia and Far East Region</u>

The main oil transport route between Western Siberia and Eastern Siberia is the 48-inch Omsk (6) - Angarsk (21) pipeline, whose total length is 2,100 km. This pipeline, which begins in Tuimazy (31) in the Volga region, was originally built for the transmission of Volga oil to Western Siberia, but by 1970 Western Siberia oil was flowing both east and west through the line from Omsk.

At present a 48-inch, 818 km pipeline connecting Aleksandrovskaye (8) with Anzhero-Sudzhensk (12) is under construction, and when completed, this pipeline will carry Central Ob crude directly to Eastern Siberia refineries. Currently, this crude reaches Anzhero-Sudzhensk through a circuitous pipeline route: Aleksandrovskaye to Ust Balyk (20), Tobolsk (9), Omsk, Novosibirsk (4), and Anzhero-Sudzhensk (12).

A second crude oil pipeline from Anzhero-Sudzhensk to Krasnoyarsk (32) and Angarsk, having a total length of 1,478 km, is under construction and will double the current volume of oil being transported eastward through the existing Anzhero-Sudzhensk - Krasnoyarsk - Angarsk pipeline.

Currently, several million tons of oil and oil products are still transported by railroad from Western Siberia into Eastern Siberia and farther, into the Far East region. The Trans-Siberian rail line from Anzhero-Sudzhensk to Krasnoyarsk, Angarsk, Chita (33), Khabarovsk (34) Komsomolsk-na-Amure (35), Vladivostok (36), and Nakhodka (37) serves as the transport route for Western Siberia crude and petroleum products. The rail distance between Anzhero-Sudzhensk and Angarsk is 1,550 km; between Anzhero-Sudzhensk and Chita, 2,450 km; and between Anzhero-Sudzhensk and Nakhodka, 5,300 km. The main oil refineries in the Eastern Siberia region are located in Krasnoyarsk and Angarsk; and the principal Far East refineries for Western Siberia oil are located at Khabarovsk, Komsomolsk-na-Amure, and Nakhodka.

The rail traffic of eastward bound oil freight from Western Siberia will diminish drastically with the completion of the Surgut (2)-Khabarovsk, Khabarovsk-Komsomolsk, and Khabarovsk-Nakhodka pipelines, which have begun construction during the ninth five-year plan (1971-75).

In terms of conventional fuel, fuel oil comprises only 4 to 5 percent of the general fuel balance for Eastern Siberia (with 82-84 percent falling to coal and 12-13 percent to wood), and the proportion of fuel oil to other forms of energy fuel used in the region is expected to remain at this level throughout the decade. The relative costs of Western Siberia fuel oil to costs of other forms of fuel in Eastern Siberia is shown in Table C-26.

The uses of fuel oil in Eastern Siberia are as follows:

Electric-power stations	1.8 percent
Industrial boilers	5.7
Technological needs	22.7
Transportation	18.4
Residential and private needs	51.4

Table C-26

COSTS OF WESTERN SIBERIA FUEL OIL COMPARED TO COSTS OF COAL IN EASTERN SIBERIA
(Rubles per Ton of Conventional Fuel)

Point of Demand	Eastern Siberia Coal				W. Siberia Fuel Oil
	Kanske-Achinsk	Cheremkhovets	Gusino Ozero	Kuzbass	
Krasnoyarsk	1.9	4.1	-	3.6	3.8
Irkutsk	3.6	2.7	6.3	-	3.9
Ulan Ude	-	3.6	5.4	-	4.9
Chita	-	4.4	6.4	-	5.5

In the Far Eastern region, coal will also remain the main source of fuel energy in the future, although the proportion of fuel oil used in this region is much higher (about 30 percent of total) than in Eastern Siberia. This is partly the result of the extensive use of truck transport for carrying oil freight and coal over long distances in the Yakutsk (40) - Magadan (41) area of the region. Other than the Trans-Siberia line, there are no rail lines in the entire Far East. The end-use demand for oil in the Far East is as follows:

Electric power stations	0.8 percent
Industrial boilers	15.0
Technological needs	21.2
Transportation	51.7
Other	11.3

Rivers and the Pacific Ocean are also used for the transport of oil in the Eastern Siberia and Far East economic regions. In 1970 several hundred thousand tons of Western Siberia oil products were

shipped up the Yenisei and Angara Rivers from Krasnoyarsk; and some of the Western Siberia oil arriving at Nakhodka in 1970 was shipped by ocean-tanker to Magadan (41) and on up to Pevek (42), in the far north.

6. Caucasus Oil Transport

Figure C-8 presents the map for oil transport relating to the Caucasus.

a. Caucasus Oil Fields

The Baku oil fields in the Azerbaijan republic are the oldest oil fields drilled in the USSR. As recently as World War II, Baku was supplying 70 percent of the nation's crude oil; but in 1970, the 20 million metric tons of crude produced at Baku represented less than 6 percent of the total production of crude in the USSR.

The principal oil refineries in the Caucasus are located in Baku (1) and in Batum (2). These two cities are connected by the Caucasian rail line, 850 km, and by crude oil pipeline. In addition, a second pipeline for the transmission of oil products is under construction between the two cities. The crude oil pipeline consists of three 8-inch pipes with a length of 830 km. The relatively small diameter of these pipelines reflects the fact that they are among the oldest pipelines laid in the USSR.

The railroad and the pipelines pass through the cities of Kirovabad (3) 275 km from Baku; Rustavi (4), 450 km from Baku; and Tbilisi (5), 575 km from Baku. Kirovabad contains food-processing and textile plants and a thermal electric power station. Rustavi has chemical, iron and steel making, and cement plants. Tbilisi, the capital of the Georgian republic, has transport machinery plants; engineering machinery, and metal-finishing plants; food-processing and textile plants; and both a thermal electric and a hydroelectric power plant.

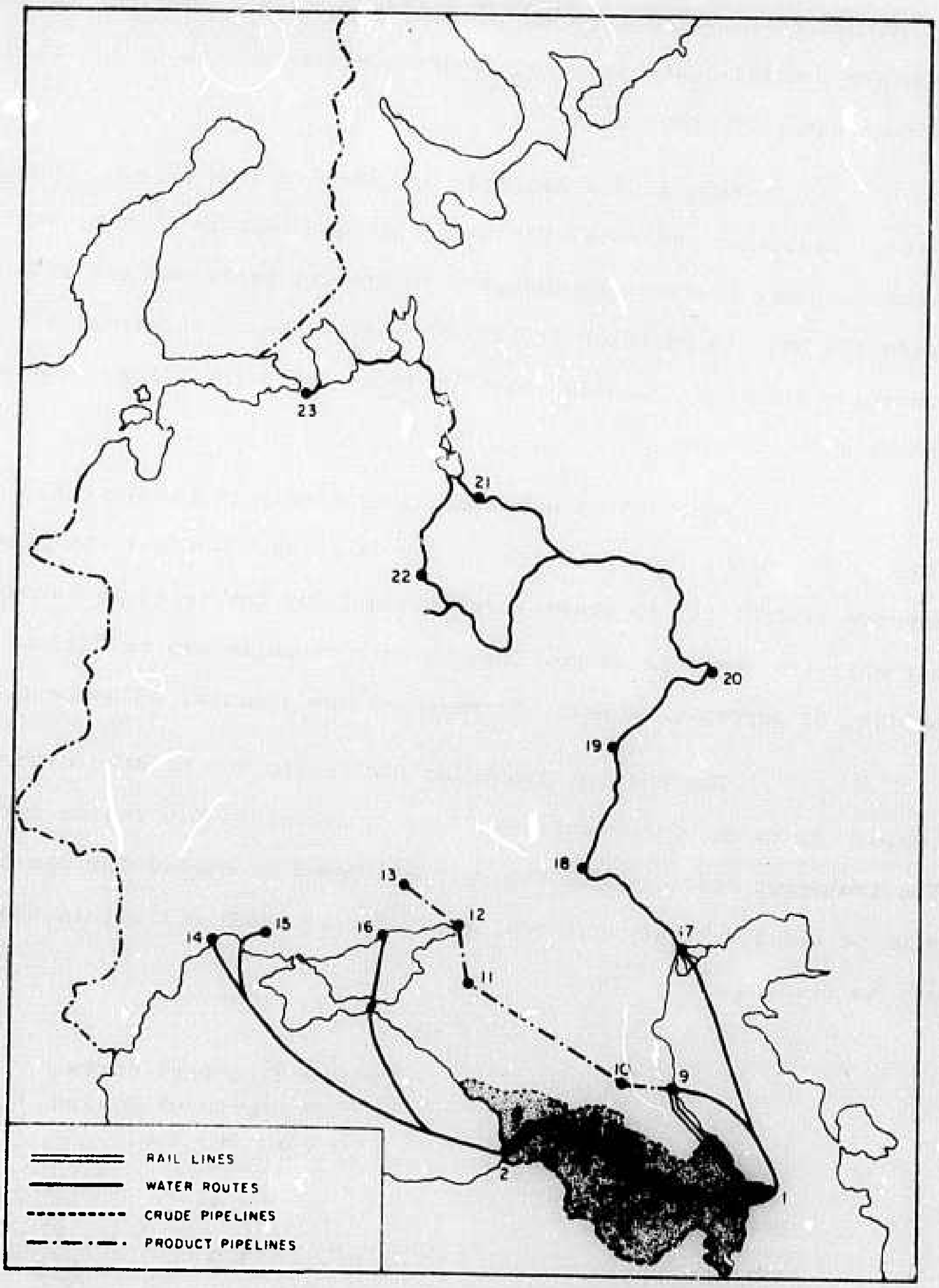

Figure C-8

CAUCASUS OIL TRANSPORT

The pipelines and the rail line also pass through the city of Kutaisi (6), 700 km from Baku. Kutaisi contains chemical, transport machinery, metal-finishing, and food-processing plants in addition to a thermal electric power plant.

Baku itself has iron and steel-making plants, chemical plants, machinery and metal-finishing plants, textile plants, and a thermal electric power station, in addition to its oil wells and oil refineries. Batum (2) has, in addition to its oil refineries, a machinery and steel-finishing industry, chemical plants, food-processing plants, and a lumber industry.

Fuel oil is used more extensively in the Azerbaijan republic than in the other two republics of the Caucasus. Whereas the general proportion of fuel oil to other forms of fuel for the total Caucasus is 52 percent, the specific proportions in each republic are as follows: Azerbaijan, 61 percent; Georgia, 37 percent; and Armenia, 46 percent.

The cost of producing one metric ton of Baku crude is 8 rubles; in terms of conventional fuel, the cost is 5.6 rubles per ton. The transport costs (including rail and pipeline costs) for the transmission of one ton of conventional fuel of Baku crude oil within the Caucasus are as follows:

Region of Fuel Demand	Average Transport Costs for each Region of Demand (rubles per ton)
Georgia	2.8
Azerbaijan	1.9
Armenia	3.6
The Total Caucasus	2.5

These costs are based partly on the relative volume of fuel oil transported to each republic.

The uses of Caucasus oil in the Caucasus are as follows: electric power stations, 34.9 percent; industrial boilers, 22.4 percent; technological needs, 19.0 percent; transportation, 19.7 percent; other uses, 4.0 percent.

A few hundred thousand tons of oil per year have been produced regularly since the sixties in oil fields located in Georgia near Mirzaani (7), where the crude is refined. Georgian oil products are used solely within the vicinity of Mirzaani and are transported by rail to the metal-finishing and machinery plants of Telavi (8), 75 km from Mirzaani, and to Tbilisi, 75 km from Mirzaani.

b. Caucasus Oil Transport to Northern Caucasus

Crude and oil products from the Baku refinery are shipped by ocean tanker to the Northern Caucasian port of Makhachkala (9), 300 miles from Baku and some oil products are transported along the Caspian line of the Caucasian and Northern Caucasian rail systems from Baku to Makhachkala--a rail distance of 350 km. Oil products are then pumped through the Makhachkala-Groznyi (10) crude pipeline and the Groznyi-Tikhoretsk (11)-Rostov (12)-Trudovaya (13) product pipeline into the Donets-Dnieper region, where they are distributed throughout the Donets-Dnieper, Central Blacksoil, Central, and Northwestern regions primarily by the Kursk, Moscow, October, and Northern rail lines.

c. Caucasus Oil Transport to Southern Region

Oil products from Batum are shipped by ocean tanker to Odessa (14), Kherson (15), Berdyansk (16), and other seaports on the Black Sea and Sea of Azov as well as to other countries. Kherson, 675 miles from Batum, has a large ship-building industry in addition to

machinery and steel finishing plants, textile and food-processing plants, a glass industry, and a thermal electric power station. Berdyansk, on the Sea of Azov 500 miles by sea from Batum, has food-processing and machinery plants.

d. Caucasus Oil Transport to Volga Region

Combination ocean-river tankers carry oil products from Baku to Astrakhan (17), a distance of 475 miles, from where they are shipped up the Volga River route. At Volgograd (18), Saratov (19), and Kuibyshev (20), oil products from Baku are mingled with those from the Volga region. The oil transport river route runs along the Volga River to Yaroslavl (21); from Yaroslavl along the Volga and Moscow Rivers to Moscow (22); and along the canal system connecting the Volga with Lake Ladoga to Leningrad (23).

7. Central Asia Oil Transport

Figure C-9 presents the map for oil transport relating to Central Asia.

In 1970 about 17 million metric tons of crude oil were produced in the oil fields of the Central Asian Economic Region. Most of the drilling was done in the Turkmen fields (near item 2 on Figure C-8), which yielded 14.5 million tons in 1970. The other fields include: the Uzbekistan fields, which produced approximately 2 million tons in 1970; the Kirghizian fields, producing about 250,000 tons the same year; and the Tadzkikstan (21) oil fields, which produced about the same tonnage as the Kirghizian fields.

In the Turkmen fields, a system of pipelines and rail lines connect the various drilling areas with the seaport-refinery of Krasnovodsk (1). The main rail holding stations are Vyshka (2) and

Figure C-9

CENTRAL ASIA OIL TRANSPORT

Krasnovodsk. About two-thirds of the oil drilled in the Turkmen fields is refined in Krasnovodsk, but in 1970 5.5 million tons of crude were shipped by ocean tanker from Krasnovodsk to the Caucasian refineries at Baku (3), 200 miles; the Northern Caucasian refineries at Makhachkala (4), 350 miles; and the Kazakhastan refineries in Guriev (30), 650 miles. At present, two underwater crude oil pipelines connecting the Turkmen fields with Baku are planned, although construction has not yet begun.

Most of the oil products produced at Krasnovodsk are transported to other points in Central Asia by rail. The Central Asian, oil-freight rail line runs from Krasnovodsk, which contains machine production and metal-finishing plants and a thermal electric power station as well as oil refineries, to Ashkhabad (5), a large industrial city with machinery and metal-finishing plants; building-material, textile, food-processing, and cement plants; and a thermal electric power station. Ashkhabad is 550 km by rail from Krasnovodsk.

From Ashkhabad the rail line continues to Chardshou (6), a machinery, chemical, textile, and mineral-fertilizer production center 600 km, by rail from Ashkhabad. From Chardshou, some of the oil-product rail-freight continues along the eastern Turkmen line through a number of small towns with chemical, textile, and food-processing plants--e.g., Urgench (7), Nukus (8), and Kungrad (9). One of these small towns, Takhia-Tash (10), has a thermal electric power plant. (Takhia-Tash is located 450 km from Chardshou.)

Some of the oil-product freight arriving in Chardshou from the Turkmen fields continues along the more westerly line of the Central Asian rail system to Samarkand (11), a large industrial city 400 km by rail from Chardshou and 1,550 km from Krasnovodsk. Samarkand has chemical, textile, food-processing, and machinery and metal-finishing plants, and is the location of both a hydroelectric plant and a thermal electric power plant.

Ursatyeoskaya (12) is located 100 km east of Samarkand, and is a rail junction and station for oil-product storage. In addition to Turkmen oil from the western end of Central Asia, Ursatyeoskaya also receives oil-products from the Uzbek and Kirghizian fields which arrive by rail from the east.

The transport distance traveled by oil-products from the Krasnovodsk refineries will be considerably shortened when the pipeline from Krasnovodsk to Chardshou, currently under construction, is completed. This is a 48-inch, 950 km crude oil pipeline, which will also transfer some of the burden from the Krasnovodsk refineries to new refineries that will be built in Chardshou.

Tadzkikstan crude oil, about 0.25 million metric tons per year, is refined in Termez (21), which is located in the middle of the Tadzkik oil fields. Refineries in Fergana (13) receive, via two 75 km pipelines, about 2 million metric tons per year from the Uzbekistan oil field and about 0.25 million metric from the Kirghizian oil field.

Along the 325 km stretch between the rail stations of Fergana and Ursatyevskaya are a number of cities which receive oil products from Fergana. These cities include: Kokand (14), which has chemical, mineral fertilizer, food-processing, and machinery-production and metal-finishing plants; Leninabad (15), which has the same industries as Kokand in addition to a building-material industry; and Begovat (16), which contains a thermal electric power station, cement plants, iron and steel making plants, and a building-material industry.

The oil products arriving in Ursatyevskaya from Fergana and Krasnovodsk are transported north by rail to Tashkent (17), a large industrial city with both a thermal and a hydroelectric power plant. Tashkent is 225 km by rail from Ursatyevskaya, 550 km from Fergana, and 1,925 km from Krasnovodsk.

As late as the middle sixties, a large volume of Central Asia refined oil was transported along the eastern Kazakh rail line to Semipalatinsk (18), 2,100 km from Tashkent, and farther, to the stations of Barnaul (19) and Novosibirsk (20), 700 km from Tashkent, 400 km from Fergana, and 1,900 km from Krasnovodsk. Most of this oil transport had become unnecessary by 1970 as a result of the vigorous development of the Western Siberia fields. Currently, an oil pipeline is under construction for the transmission of Western Siberia oil to eastern and southern Kazakhstan. Nevertheless, in 1970, 2.2 million tons of oil products were transported by rail from Central Asia to Chimkent (21) and other cities in southern Kazakhstan.

The uses of fuel oil in Central Asia are as follows: 33.8 percent for electric power stations, 22.8 percent for industrial boilers, 29.8 percent for technological needs, 9.8 percent for transportation, and 3.8 percent for various other needs.

The comparative costs of Kuzbass coal and Turkmen and Uzbek fuel oil in different cities of Central Asia are given in Table C-27.

Table C-27

COSTS OF CENTRAL ASIA FUEL OIL COMPARED TO COSTS OF KUZBASS COAL
(Rubles per Ton of Conventional Fuel)

Point of Demand	Uzbek Fuel Oil (Fergana)	Turkmen Fuel Oil (Krasnovodsk)	Kuzbass Coal
Tashkent	8.7	9.2	15.3
Samarkand	9.0	8.2	16.1
Fergana	7.5	-	16.3
Ashkhabad	-	6.0	18.2
Alma-Ata (22)	11.9	12.3	12.6

Source: A. Probst, Razvitie toplivnoi basy rainov SSR, "Nedra," Moscow, 1968.

8. Kazakhstan Oil Transport

Figure C-10 presents the map for oil transport relating to Kazakhstan.

In 1970 about 13.5 million metric tons of crude oil were produced in Kazakhstan, of which about 3 million tons were from the traditional Emba River fields in the vicinity of Guriev (1), and the remainder from the relatively recently developed Mangyshlak Peninsula fields in the vicinity of Shevchenko (2), Zhetibay (3), and Uzen (4). Kazakhstan's oil refineries are located at Guriev.

A large part of the oil produced in Kazakhstan is transported, primarily by pipeline, to other regions. Within Kazakhstan, oil produced in the region is used primarily in Western Kazakhstan. In Southeastern and Eastern Kazakhstan, oil comes primarily from Western Siberia and Central Asia. The fuel demand by type of fuel for different parts of Kazakhstan in 1970 is shown in Table C-28.

Table C-28

FUEL DEMAND IN KAZAKHSTAN BY TYPE OF FUEL - 1970
(Percent)

Region of Kazakhstan	Coal	Fuel Oil	Gas	Other
Western Kazakhstan	40 %	34 %	17 %	9 %
Southern Kazakhstan	41	2	53	4
Tselinograd region (6)	92	2	2	4
Alma-Ata region (7)	62	9	24	5
Eastern Kazakhstan	94	2	1	3
Semipalatinsk region (8)	87	5	2	6
Karaganda region (9)	84	3	1	12
Kazakhstan as a whole	76	5	12	7

Figure C-10

KAZAKHSTAN OIL TRANSPORT

A 40-inch, 200 km pipeline connects the oil fields in the Mangyshlak Peninsula to Uzen, from which crude oil is piped 450 km to refineries in Guriev.

Some of the Mangyshlak crude oil is shipped by ocean tanker via the Mangyshlak gulf port of Shevchenko, to Astrakhan (11) for refining. In 1970, 3.7 million tons of Mangyshlak crude was shipped to Astrakhan by ocean tanker.

In Guriev, local Emba oil is also processed. Much of the crude in Guriev is sent by pipeline to the refineries at Orsk (12) in the southern Urals, located a distance of 700 km by pipeline from Guriev. From Orsk, the refined products are distributed throughout the Southern Urals by rail.

Most of the crude oil in Guriev, however, is sent through the 40-inch Guriev-Kuibyshev (13) pipeline, which stretches some 1,050 km to Kuibyshev. Some of the Kazakhstan grade is processed in Kuibyshev, and a rather large quantity of the crude sent through the Druzhba pipeline to Belorussia and the Baltic. Some of the processed Kazakhstan oil in Kuibyshev is sent through the oil product pipeline running parallel to the Druzhba pipeline from Kuibyshev in the Volga region to Bryansk (14) in the Central Region.

Railroads have not been entirely superseded by pipelines in Kazakhstan, and in 1970, nearly 6 million tons of oil products and crude oil were transported along the Western Kazakh rail system 500 km to Kandagach (15), from which some continued in a southerly direction to the Aral Sea and beyond to Arys (16), 1,200 km, and the rest along the Kandagach-Aktyubinsk (17) and Kandagach-Orsk lines. In 1970, about 4 million tons of Kazakh oil (primarily crude) were transported by rail to Orsk.

9. Ukraine and Belorussia Oil Transport

Figure C-11 presents the map for oil transport relating to Ukraine and Belorussia.

a. Oil Fields of Ukraine and Belorussia

The Carpathian oil fields of the Western Ukraine in the vicinity of Uzhgorod (3) have been drilled continuously since the 19th century, and in 1970 they were still yielding above 2 million metric tons annually. The Chernigov (1) oil fields of the Central-Eastern Ukraine region have been in operation for 15 to 20 years, and their annual output in 1970 was 11.5 million tons.

Production of crude oil in Belorussia began in 1965, and by 1970 the region was producing over 4 million tons annually. The Belorussian oil fields are located in the vicinity of Mozyr (2).

The main West Ukrainian refineries are situated at Uzhgorod, which processes local Carpathian crude as well as crude piped from the Volga-Urals oil region through the Druzhba pipeline, which passes through Uzhgorod on its way into Czechoslovakia and Hungary. In the Eastern Ukraine the principal oil processing city is Kremenchug (4). Whereas the Carpathian wells are located within just a few kilometers of the Uzhgorod refineries, the Chernigov wells are more spread out and are connected to the Kremenchug refineries by pipelines and rail lines.

The main Belorussia refinery is located at Mozyr. Mozyr, like Uzhgorod in the Carpathian oil fields, is a pipeline junction for the Druzhba pipeline, which divides at Mozyr into the Mozyr-Uzhgorod and the Mozyr-Brest (5) pipelines. From Brest, Volga crude is transmitted through the Druzhba pipeline to Poland and East Germany.

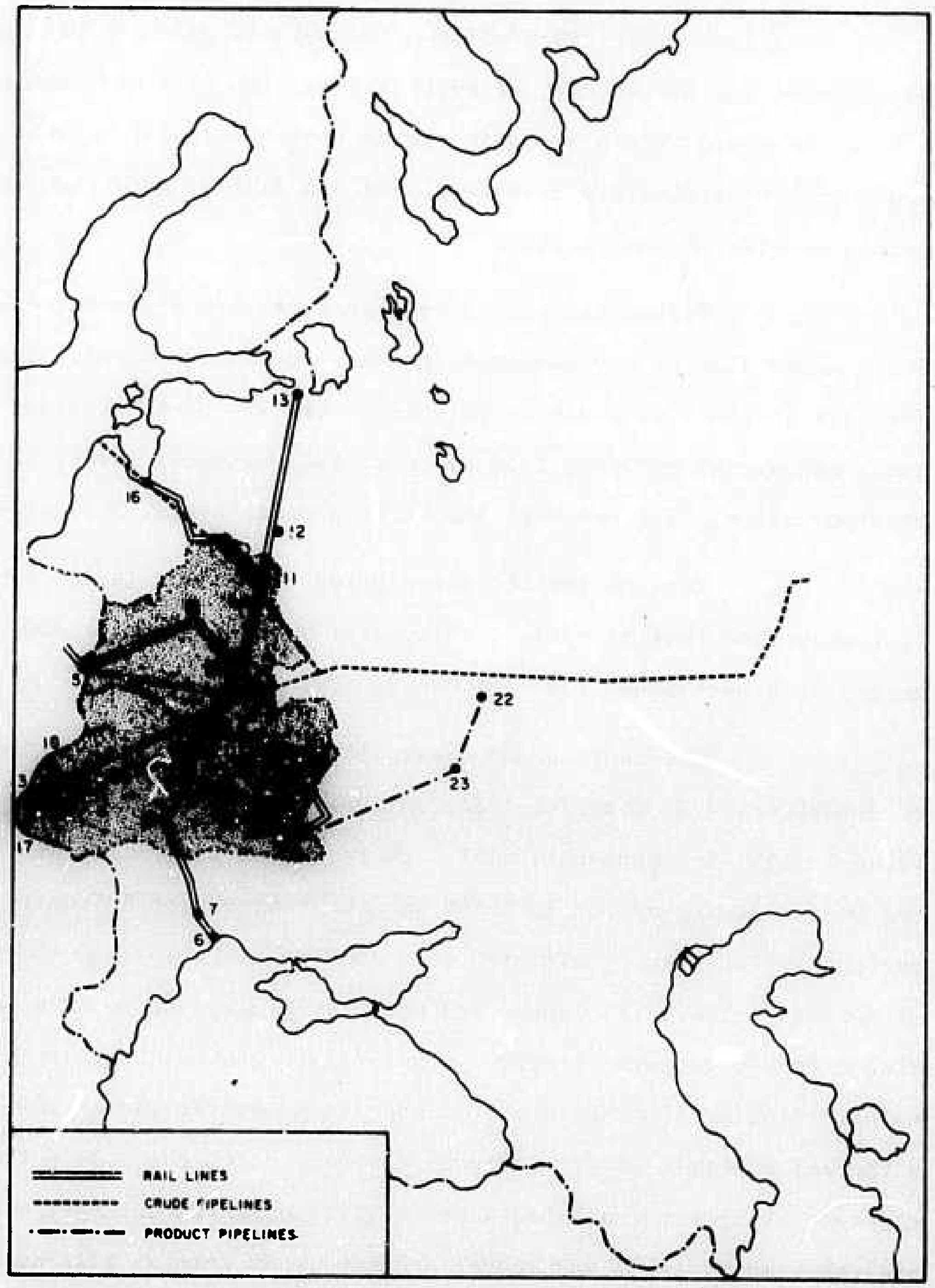

Figure C - 11

UKRAINE (SOUTHWESTERN REGION) AND BELORUSSIA OIL TRANSPORT

b. Ukraine Oil Transport

In 1970, 12.7 million tons of oil products were produced at Uzhgorod and Kremenchug, of which 7.2 million were distributed by rail within the Southwestern economic region (where both the Carpathian and the Chernigov fields are situated), and 5.5 million were exported to points outside of the region.

Within the region, oil products are distributed by virtually every major line of the Southwestern and Lvov rail systems. The uses of fuel oil in the region are as follows: electric power stations, 20.7 percent; industrial boilers, 18.7 percent; technological needs, 25.5 percent; transportation, 31.6 percent; and various other needs, 3.5 percent.

Most of the oil transported out of the region from Kremenchug is transported west by rail to Zhitomir (9), a distance of 400 km, where it merges with northbound oil from Odessa (6).

This northbound Odessa rail line runs through the cities of Razdelnaya (7), Zhmerinka (8), Zhitomir (9), Korosten (10), Orsha (14), Vitebsk (11), Novosobolniki (12), and Leningrad (13). The distance of the Odessa-Leningrad run is 1,550 km, and that of the Zhitomir-Leningrad section is 1,075 km. Zhitomir is an industrial center for the production of building materials, lumber products, machinery and metal products, and also a food-processing center. Orsha (14) contains machinery-producing, metal-finishing, food-processing, and linen-textile plants in addition to a thermal electric power station. Vitebsk, which has both a thermal electric station and a hydroelectric station, produces heavy machinery and other metal goods and lumber products. At Vitebsk (11) an auxiliary rail line from the Odessa-Leningrad oil run leads to the Baltic seaport of Riga (16).

At Korsten (10), a significant part of the oil cargo on the main Odessa-Leningrad line is directed westward to Chop (17), from

which oil products continue by rail into Hungary and Czechoslovakia. Some of the crude from Odessa via Korsten goes to Mostiska (18), from which oil freight is transmitted by rail into Poland and East Germany. Soviet oil products also enter Poland from the Belorussian rail station of Brest, to which oil products are sent from the Odessa-Leningrad line via the auxiliary line Zhlobin (20)-Minsk (21)-Brest.

Finally, some of the oil products from Kremenchug refineries are sent to Michurinsk (22) in the Central region via a 24-inch pipeline running 475 km from Kremenchug to Liski (23) in the Central Blacksoil region, and 225 km to Michurinsk.

c. Belorussia Oil Transport

In 1970, 14.3 million metric tons of oil products were processed at Mozyr, of which 8 million were distributed throughout Belorussia by rail, and the remainder was transported outside the region by rail.

Mozyr is situated on the Odessa-Leningrad rail line described in part (b) of this section, and part of the Mozyr oil freight leaving Belorussia is transported along this line. Part of the exported oil products are shipped through Minsk to Brest, where they are exported by rail into Poland.

About 16 percent of the total conventional fuel tonnage used in Belorussia consists of fuel oil. The relative use of other energy fuels in Belorussia is as follows: coal, 32 percent; gas, 17 percent, peat, 24 percent; wood, 9 percent; other fuels, 2 percent.

The end uses of fuel oil within Belorussia are apportioned as follows: electric power stations, 9 percent; industrial boilers, 19.4 percent; technological needs, 46.6 percent; transportation, 24.5 percent; other needs, 0.5 percent.

10. Northwestern Oil Transport

Figure C-12 presents the map for oil transport relating to the Northwestern region.

Most of the 6 million tons of crude produced at Ukhta (1) in 1970 were processed in Ukhta's refineries. Some of the crude, however, was transported along the Northern rail line to Yaroslavl (2) for refining--a rail distance of 1,250 km. In 1970 about 2 million tons of crude were transported by rail to Yaroslavl from Ukhta.

Ukhta's oil products are used almost entirely within the Northwestern region and are transported along the Northern and October rail lines to Syktyvkar (3), 400 km; Vologda (4), 1,000 km; Cherepovets (5), 1,150 km; Leningrad (6), 1,600 km; Arkhangelsk (7), 850 km; and Murmansk (8), 1,200 km. The total volume of Ukhta oil products transported within the Northwestern region in 1970 amounted to 11.1 million metric tons.

At present, a 40-inch, 1,550 km crude oil pipeline is under construction between Ukhta and Yaroslavl.

The uses of fuel oil in the Northwestern region are as follows: 11 percent for electric power stations, 11 percent for industrial boilers, 33 percent for technological needs, 43 percent for transportation, and 2 percent for other uses.

11. Far East Oil Transport

Figure C-13 presents the map for oil transport relating to the Far East.

There are several oil fields under development in the Far East region--on the upper Lena at Markovo (1); in the central Yakutiia district at Russkorechensk (2), Tolbinsk (3), Pokrovsk (4), Kangalassy (5), and Oloisk (6); and in Northern Sakhalin at Okha (7). However, only the Okha fields on Sakhalin were producing by 1970.

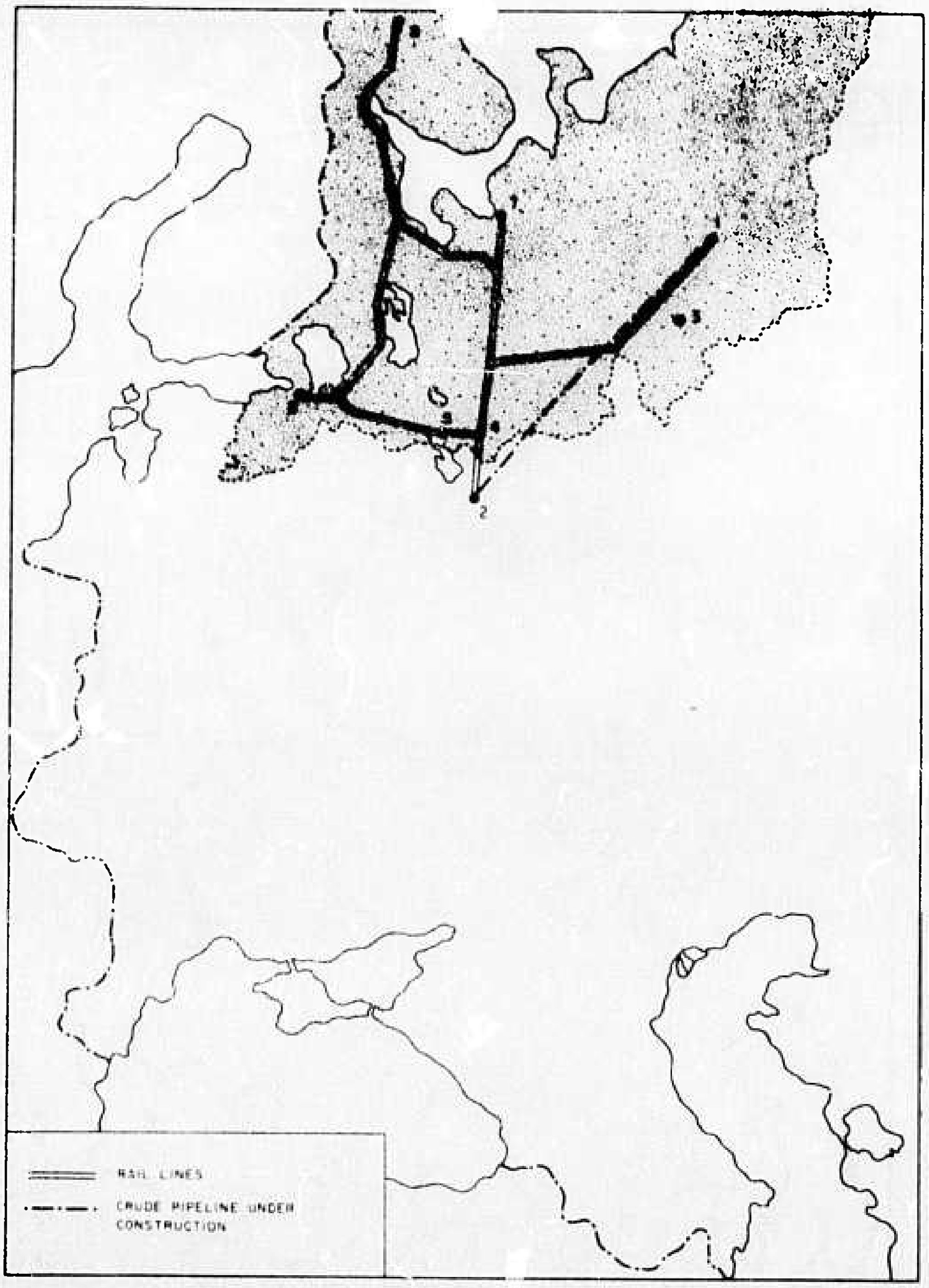

Figure C-12

NORTHWESTERN REGION OIL TRANSPORT

Figure C-13

FAR EAST OIL TRANSPORT

Oil products arriving in Markovo and in the Yakutsk (8) areas were still being produced from Western Siberia crude in the Eastern Siberia refineries at Angarsk (9), from which the products were shipped by rail to Osetrovo (10), and then by river tanker down the Lena river to Markovo and Yakutsk. Some Soviet planners in the Gosplan Institute hope to develop the oil fields in Markovo and Central Yakutiia after 1975 in order to relieve the transport burden on Angarsk oil products shipped along this difficult and seasonal route. Other planners in the Gosplan Institute prefer to extend crude pipelines from other regions into the area since pipeline and refinery construction would be cheaper than the establishment of oil wells in what is a difficult geological structure in the upper Lena and Central Yakutiia fields. Over 25 percent of the fuel used in Central Yakutiia consists of fuel oil, almost all of which is used in the transportation sector of Yakutiia's economy.

Refineries are located at Okha, Nikolaevsk (11), Komsomolsk (12), and Khabarovsk (13). A double-string crude pipeline runs from Okha to Nikolaevsk and Komsomolsk. Oil used in Sakhalin is refined in the refineries of Okha and dispatched by narrow-gauge railway to Poronaysk (14), where it continues along the Southern Sakhalin rail system.

Most of the 2.5 million metric tons of crude produced at Okha is sent through the pipelines to the mainland. At Nikolaevsk, 175 km from Okha, oil products for the city are produced in the local refinery. A large part of the crude arriving in Komsomolsk, 400 km from Nikolaevsk, is processed in the local refinery, from which oil products are shipped along the Amur rail system to various points of fuel oil demand. Some of the oil products and a large part of the crude are shipped by river tanker from Komsomolsk down the Amur to Khabarovsk, 350 km, and the remainder by rail along the Komsomolsk-Khabarovsk rail line, a distance of 475 km.

Khabarovsk has the largest refineries in the Far East and produces oil products both from Sakhalin crude and Western Siberia crude shipped along the Trans-Siberian railroad.

Khabarovsk oil products are transported to demand points in the Amur and Primorye regions by rail--i.e., along the Amur River rail line and along the Khabarovsk-Vladivostok (15)-Nakhodka (16) rail line. The transport system of the Far East economic region relies heavily on its river-system; in 1970 nearly 1 million tons of crude and oil products were shipped along the Lena and Amur Rivers.

Ocean routes are also used extensively, and in 1970 nearly half of the oil products produced in the Far East region (3.1 million out of a total of 7.3 million tons of crude and oil products transported within the region) were shipped by ocean tanker from the ports of Vladivostok and Nakhodka. The destinations of the products included southern Sakhalin island through the port of Kholmsk (26); Magadan (17); Kurilsk island through the port of Severo-Kurilsk (18); Petropavlovsk-Kamchatskii (19); Ust-kamchatsk (20); and Pevek (22).

The fuel consumption by type of fuel for different regions within the Far East is given in Table C-29.

The uses of fuel oil in the Far East region are as follows: electric-power stations, 0.8 percent; industrial boilers, 15.0 percent; technological needs, 21.2 percent; transportation, 51.7 percent; other needs, 11.3 percent.

12. Soviet Oil Exports

Soviet oil exports from 1957 to 1970 and for 1975 (estimated) are given in Table C-30. More details on oil exports by country and transport mode are given in Tables C-31 and C-32).

Table C-29

COMPARATIVE ENERGY FUEL USAGE BY TYPE OF FUEL
IN CERTAIN REGIONS OF THE FAR EAST
(Percent, Based on Tons of Conventional Fuel)

Point of Demand	Coal	Oil	Wood
Primorye (Nakhodka)	61.5%	33.6%	4.9%
Khabarovsk	58.0	35.7	6.3
Amur	74.0	20.2	5.8
Kamchatka	37.1	53.0	9.9
Magadan	67.8	27.1	5.1
Yakutiia (Yakutsk)	43.7	25.5	30.8
Sakhalin (Kholmsk)	68.9	27.6	3.5

Table C-30

SOVIET OIL EXPORTS
(Million Metric Tons)

Year	Exports (million metric tons)	Percent
1957	14	
1960	33	+33% per year
1965	64	+14
1968	86	+10
1970	95	+ 5
1971	97	+ 2
1975 (estimated)	107	+23

Source: Soviet trade statistics.

Table C-31

CRUDE OIL AND OIL PRODUCTS EXPORTED FROM THE USSR
(f.o.b. Russian Border)

Country of Destination	1970 Amount (thousand tons)	1970 Value (thousand rubles)	1971 Amount (thousand tons)	1971 Value (thousand rubles)
Afghanistan	141	5,293	147	5,513
Austria	1,053	13,985	1,126	17,953
Belgium	1,275	17,446	2,039	30,849
Bulgaria*	7,050	102,756	7,959	116,324
Cuba	5,987	69,175	6,444	73,542
Cyprus	135	1,355	204	2,662
Czechoslovakia*	10,500	167,941	11,811	191,510
Denmark	377	3,343	861	10,353
Egypt	1,638	25,704	1,604	31,841
Federal Republic of Germany	6,223	79,638	6,092	94,067
Finland	7,775	107,903	8,567	166,357
France	2,500	30,185	4,539	68,317
German Democratic Republic	9,342	125,202	10,378	141,101
Ghana	515	5,183	598	8,671
Greece	928	12,027	1,011	16,779
Guinea	61	1,769	71	2,079
Hungary*	4,759		5,055	
Iceland	380	6,716	379	8,590
India	252	4,315	473	9,830
Ireland	235	1,800	335	3,244
Italy	10,195	96,767	9,002	117,673
Japan	2,700	30,098	3,300	44,700
Mongolia	261	11,022	267	11,226
Morocco	699	7,691	868	12,108
Netherlands	1,444	23,541	1,631	28,951
North Korea	838	27,721	700	23,397
North Vietnam	353	12,321	375	12,846
Norway	566	2,163	628	11,490
Poland*	8,642	143,000	9,550	158,075
Somalia	59	1,393	73	1,698
Spain	122	928	214	4,040
Sweden	4,818	46,941	4,569	59,057
Switzerland	445	8,514	805	16,777
Syria	47	936	0	3
Turkey	185	3,821	69	1,979
Yemen Arab Republic	17	420	1	19
Yugoslavia*	2,740	36,554	2,880	52,393
Grand Total	95,256	1,235,567	97,463	1,556,014
COMECON Total	38,274†		42,567‡	

* COMECON country.

† 45 percent of total.

‡ 49 percent of total.

Table C-32

EXPORTS OF CRUDE OIL AND OIL PRODUCTS FROM THE USSR BY COUNTRY AND TRANSPORT MODE
1970

Country of Destination	Amount (1,000 tons)	Cost (1,000 rubles)	Transport Mode	Approximate Distance (km and mi)
1. Austria	1,053.4	13,985	Danube tanker-Odessa-Constanta-Vienna R.R.: Chop-Budapest-Vienna	2,300 km. 550 km.
2. Afghanistan	140.7	5,293	R.R.: Krasnovodsk-Kushka-Herat	1,400 km.
3. Belgium	1,275.1	17,446	R.R. Brest-Berlin-Enschede-Brussels Ocean Tanker-Ventspils-Oostende	1,500 km. 1,200
4. Bulgaria	7,049.7	102,756	Ocean Tanker-Novorossiisk-Varna, Burgas River Tanker-Constanta-Ruse, R.R. Reni-Galati-Varna	600 km. 250 km; 400 km.
5. North Vietnam	953	12,321	Ocean Tanker-Nakhodka-Haiphong	2,550 mi.
6. Ghana	515.0	5,183	Ocean Tanker-Odessa-Sekondi	3,800 mi.
7. Guinea	60.7	1,769	Ocean Tanker-Odessa-Conakry	2,250 mi.
8. GDR	9,342.2	125,202	R.R.: Brest-Berlin Pipeline-Kiubyshev-Brest-Schwedt	750 km.
9. Greece	928.1	12,027	Ocean Tanker-Odessa-Salonika	900 mi.
10. Denmark	376.8	3,343	Ocean Tanker-Ventspils-Copenhagen	500 mi.
11. Egypt	1,638.1	25,704	Ocean Tanker-Odessa-Alexandria	1,300 mi.
12 India	251.9	4,315	Ocean Tanker-Odessa-Bombay	5,300 mi.
13. Ireland	234.5	1,800	Ireland-Ventspils-Dublin	2,000 mi.
14. Iceland	379.9	6,716	Ocean Tanker-Ventspils-Reykjavik	2,000 mi.
15. Spain	122.1	926	Ocean Tanker-Odessa-Barcelona	2,100 mi.
16. Italy	10,194.7	96,767	Ocean Tanker-Odessa-Naples	1,700 mi.
17. Yemen Arab Republic	16.9	420	Ocean Tanker-Odessa-Al Hu d aydah	2,900 mi.
18. Cyprus	134.9	1,355	Ocean Tanker-Odessa-Nicosia	1,300 mi.
19. North Korea	838.3	27,721	R.R.: Ussuriyak-Khasan-Korean rail system Ocean Tanker-Nakhodka-Wonsan	150 km. 400 mi.
20. Cuba	5,986.9	69,175	Ocean Tanker-Odessa-Havana	8,500 mi.
21. Morocco	689.8	7,691	Ocean Tanker-Odessa-Casablanca	1,100 mi.
22. Mongolia	260.3	11,022	R.R.: Ulan Ude-Naushki-Ulan Bator	500 km.
23. Netherlands	1,443.8	23,541	R.R.: Brest-Berlin-Enschede Ocean Tanker-Ventspils-Amsterdam	1,200 km. 1,200 mi.
24. Norway	565.7	7,163	Ocean Tanker-Ventspils-Oslo	800 mi.
25. Poland	8,641.9	143,000	R.R.: Brest-Warsaw Pipeline: Liobusjav-Brest-Plock	200 km.
26. Syria	46.8	936	Ocean Tanker-Tuapse-Latakia	1,600 mi.
27. Somalia	58.8	1,393	Ocean Tanker-Tuapse-Berbera	3,300 mi.

Table C-33 (Concluded)

Country of Destination	Amount (1,000 tons)	Cost (1,000 rubles)	Transport Mode	Approximate Distance (km and mi)
28. Turkey	184.7	3,821	R.R.: Tbilisi-Leninakan-Kara Ocean Tanker-Bakum-Trabzon-Odessa-Istanbul	300 km. 100 mi.
29. FRG	6,223.1	79,638	Numerous raillines, including Brest-Berlin-Hannover Ocean Tanker-Ventspils-Bremerhaven	900 km. 1,000 mi.
30. Finland	7,774.6	107,903	Ocean Tanker-Riga-Helsinki, Tallin-Helsinki Leningrad Helsinki R.R.: Leningrad-Viborg	 75-300 mi. 150 km.
31. France	2,500	30,185	Numerous raillines Ocean Tanker: Odessa-Marseilles	 1,850 mi.
32. Czechoslovakia	10,500	167,941	R.R.: Ughgorod-Kosice	100 km.
33. Switzerland	445.1	8,514	R.R.: Uzhgorod-Prague-Munich-Schoffhausen	1,200 km.
34. Sweden	4,818.1	46,941	Ocean Tanker-Ventspils-Stockholm	225 mi.
35. Yugoslavia	2,740.2	36,554	R.R.: Reni-Galati-Bucharest-Belgrade	800 km.
36. Japan	2,700	30,098	Ocean Tanker-Nakhodka-Niigata	500 mi.
37. Hungary	4,759	77,360	R.R.: Chop-Miscolc	150 km.

Through the early 1960s, about one-third of the USSR's oil exports were going to eastern Europe. That portion has risen to 45 percent in 1970 and 49 percent in 1971. Bulgaria is supplied by a short tanker route, but Poland and East Germany can make use of the 3,000 mile Druzhba (Friendship) pipeline from the Ural-Volga oil fields. Most of the remaining went to western Europe, especially to Italy, Federal Republic of Germany, and France; and to Finland, Sweden, Cuba, and Japan.

During the 1950s, the Russians coped with this trade by building a series of standard 12,000 ton tankers, reminiscent of the war-built American T2s, at an average rate of about seven a year. In fact, the first deliveries of this type, from Kherson and Leningrad in 1953, were also the first seagoing merchant ships to be built in Soviet yards since the war. These were supplemented by smaller vessels from Finland as well as from the home yards.

For a few years after 1962, the Russians not only built rather bigger tankers themselves, but also bought a couple of dozen large vessels from Japan and Italy. These foreign purchases almost certainly represented the Soviet Government's alarmed reaction to the international crisis that accompanied the Communist revolution in Cuba.

When Fidel Castro's regime seized the island's refineries in 1960, it became dependent on supplies of Russian crude oil, which had to be shipped thousands of miles from the Black Sea. Russian oil exports received by Cuba are given in Table C-33. To carry the oil, the Russians needed chartered tonnage quickly. However, the Western oil companies, who own a large part of the world's tanker fleet and are customers to the rest, tried to organize a boycott; and if Castro's move had not coincided with a deep slump in oil freight rates (as a result of overbuilding of ships after the 1957 Suez boom), they might have succeeded. At any rate, the message was clear, and the Russians responded

Table C-33

USSR CRUDE OIL EXPORTS TO CUBA
(Million Tons)

Year	Imports (million tons)
1960	1.6
1961	3.0
1962	3.6
1963	3.8
1964	3.4
1965	3.5
1966	3.8
1967	3.8
1970	6.0

Source: Soviet trade statistics.

to it by a rapid expansion of their own tanker fleet. In the years 1962 to 1965, the Russian tanker fleet doubled its size to a tonnage of about 3 million deadweight tons. The tanker fleet now aggregates over 5 million deadweight tons.

13. Soviet Oil Transport to 1975

Installations of crude oil pipelines in the USSR have reportedly fallen short of planned construction goals in the past few years.

Table C-34 compares average annual rates of increase in amounts of crude oil pipelines and crude oil throughputs.

Table C-34

COMPARISON OF ANNUAL RATES OF INCREASE IN CRUDE OIL PIPELINES AND THROUGHPUTS

Years	Amount Total Kilometers of Crude Pipeline (thousand kilometers)	Average Annual Increase (percent)	Total Crude Throughput (million metric tons)	Average Annual Increase (percent)
1960	11		82	
		10.5%		14%
1965	22		205	
		7.1		9
1970	31		315	
		6.5		3.5
1971	33		326	
		10.6		5.5
1972	36.5		344	

Sources: 1) Narodnoie khoziaistvo, statisticheskii ezhegodnik (1961, 1971) (The National Economy, Statistical Annuals for 1961 and 1971).

2) Neftianoie khoziaistvo, 12/72 (Oil Economy, December, 1972).

3) Transport i sviaz; statisticheskii obzor (Transport and communication statistical review), 1972.

However, crude oil pipeline construction has received increasing Soviet attention in the past three years, and shortage of pipeline kilometrage can no longer be considered a bottleneck in Soviet production and substitution of oil for coal. Table C-35 illustrates this fact.

Table C-35

ADDED CRUDE OIL THROUGHPUT PER THOUSAND KILOMETERS
OF ADDED PIPELINE - USSR
1958-1975

Time Interval	Added Crude Oil Throughput per 1,000 Kilometers of Added Pipeline
1958-1965	11,200 tons
1965-1970	12,200 tons
1971	5,500 tons
1972	5,100
1971-1975*	14,400 tons

* Planned goal.

Source: SRI estimate.

As shown in Table C-35, increases in crude throughput per added pipeline kilometrage remained about the same over the 1958-1970 period. However, this ratio dropped drastically in 1971, and the trend continued in 1972--i.e., additional throughput of crude per additional 1,000 km of pipeline has dropped markedly in the past two years, showing that crude throughput is not currently keeping up with pipeline construction. That Soviet planners recognize this problem is shown in Table C-35 by the 1971-1975 Plan goal which would result in an added throughput/added kilometrage ratio of 14,400 metric tons/1,000 km. This goal represents a reemphasis of pre-1971 values of this ratio (plus a reasonable increase).

Since Soviet oil production goals have been consistently met, and even overfulfilled in the past, it may be concluded that the real problems, currently, are inefficient pumping capacity on the existing lines, depletion of older fields, and inadequate equipment and processing facilities at newly opened fields. Actual current pipeline kilometrage is obviously more than adequate for current crude throughput capabilities, although after 1975, the cycle of emphasis may have to return once again to pipelines. The formation of The New Soviet Ministry of Oil & Gas Pipeline Construction should help to prevent the Soviet pipeline construction industry from being the scapegoat for failures in pumping and processing technologies.

E. Refining in The USSR and Eastern Europe

The rapid industrial growth and concomitant rising energy demands in Eastern Europe have focused sharply on (1) the importance of crude oil and natural gas to the economies of these countries, and (2) in turn, the economic and political effects of this oil/gas emphasis on the CMEA countries' relations with the West and the so-called "Third World." The ability to invest heavily for future growth in Eastern Europe will deperd on the capability of the USSR to exploit its vast resources of oil and natural gas. This capability is particularly important to the CMEA countries, whose primary fuel resources depend mainly on expensive and deficient coal resources. The importance of Soviet oil to the CMEA countries is evident from the fact that approximately 95 percent of their crude oil needs in 1970 was satisfied by oil imports from the USSR.

In order to assess future demands on oil supplies that the Eastern bloc countries will make, it is important to look at the refining capabilities of each of these countries as they relate to growing demands for oil products. This is particularly true of the USSR, because its

refining capability (assuming that crude oil production continues growing as in the past) will determine the available oil surpluses for exports to its satellites and the West.

The refining section of this report will assess the following:

- Refining capability of each Eastern European COMECON bloc country.
- Trends in oil product slates, based on planned individual oil product use in each of these countries.
- Current status of applied technology, where pertinent.
- Current and planned capacities in the petrochemical industries as they relate to oil and natural gas supplies.

The emphasis will be given to the USSR, in view of its crucial role in this analysis.

1. Summary and Conclusions

The Soviet bloc will in the future rely to an increasing extent on oil and gas production in the USSR. It is estimated by the Soviets that as much as 50 million metric tons of oil, or about 10 percent of their planned indigenous oil production, will be shipped to its Eastern European COMECON partners by 1975. The satellite countries in time will rely to a great extent on imports from the USSR for their energy demands, primarily on oil and gas imports for their energy growth increment.

The following general conclusions can be made about the refining industry in Eastern Europe regarding its impact on oil supplies and technology.

- It is estimated that USSR refining capacity will be 385 million metric tons per year in 1975, and 727 million tons per year by 1990.

- If the Soviet goals of 500 million tons per year of crude oil production is reached by 1975, then a surplus of approximately 90 million tons per year should be available for export (assuming an average loss of 5 percent of production in transport, handling, and processing). This should leave about 40 million metric tons per year for export outside the European COMECON bloc. This total export availability is about equal to the export level of oil and oil products achieved by USSR in 1969.

- Although the lack of capabilities in rapid introduction of primary refining capacity could make more oil available for export, the offsetting factor may be the inability to expand crude production fast enough. The slow rate of introduction of field crude processing technology and pipelines will hinder their crude production capability.

- To assure themselves of crude supplies, in case of Soviet shortfalls, the Eastern Europeans are going to increase imports of oil from the Middle East and Africa. However, these shipments should not have a significant effect on world oil supplies.

- The exports of Soviet oil products to the West, and even to their European satellites, is not likely to be a significant factor in the future, because of generally lower product quality achieved by Soviet refiners and the expense of shipping products. The expansion of refining capacities in Eastern Europe should be sufficient by 1975 to satisfy internal demands of each country for oil products, and if planned construction schedules are maintained should satisfy demands at least through 1980.

- The planned expansion of petrochemical industries in Eastern Europe and the emphasis on higher quality products will require increasing sophistication in secondary oil processing. This requirement will call for assimilation of the latest in Western technology, an area in which the Soviets are falling behind. The technological opportunities for Western cooperation are obvious.

2. Historical Background of Refining

Although present-day refining in the USSR may be considered technologically unsophisticated compared with refining in the United States or Western Europe, its origins date back to the 19th century. The industry was established around the oil producing regions of the Caucasus near Groznyi and Baku. By 1869 there were 23 operating stills in Baku, processing crude to mainly illuminating kerosene.[27] At the turn of this century, new facilities were established at Yaroslavl and Balakhna (the first approximately 160 miles northeast of Moscow, and the second close to Gorkiy) to process crude from the new producing region near the north shores of the Caspian Sea east of the Ural River.

The product slate of this refining effort was rather limited, as can be seen in Table C-36, which shows the product composition from the refineries in the Baku region in 1913.

Table C-36

PRODUCT SLATE OF BAKU REFINERIES IN 1913

Product	Percent of Total Run
Kerosene	25.1%
Lubricating and other oils	9.1
Gasoline	1.5
Residues	64.3

Source: M. M. Brenner, Ekonomika neftianoi i gazovoy promyshlenosti SSSR (Economics of the Oil and Gas Industry of the USSR), Pub. "Nedra," p. 147, Moscow, 1968.

At that time, this region accounted for almost 90 percent of all refining in Russia, with the other regions showing nearly the same product compositions. These crudes were excellent sources of lubricating stocks, and to this day, this region is the main supplier of bes quality lubricating oils.

The total refinery runs amounted to approximately 180,000 barrels per day* in 1913, with nearly 10 percent of the product being exported. The peak in oil production prior to the revolution was reached in 1902 and was not surpassed again until 1928.

The upheavals of 1905, World War I, and the revolution, which was followed by civil war, caused the refinery throughputs to fall to approximately 24,000 barrels per day by 1918. From the time of the nationalization of the oil industry in 1918 through 1926, the period was marked mainly by reconstruction of the existing facilities. By 1921-22 total refinery throughput climbed to 66,000 barrels per day and was approximately 178,000 barrels per day† by 1927-28.

By the end of the first five-year plan (1928-1932), additional capacity to handle 200,000 barrels per day had been installed, and the refinery capacity by the end of 1932 was approximately 410,000 barrels

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* This is an apparent production, obtained by subtracting exports from crude production and not accounting for losses. In actual fact, much of the produced oil was probably never refined but was burned directly. This figure is thus probably too high.

Oil refining is considered a state secret in the USSR, and production figures for refined products are hard to come by. However, one can construct an estimate of Soviet refinery capabilities, as discussed in a later section on Refinery Product Methodology. A conversion factor of 1 metric ton = 7.3 U.S. barrels is used in this section to convert the Soviet production figures for oil.

† Until 1940 statistical data in the USSR was reported on a fiscal year basis running from October 1 to September 30.

per day. 1932 was also the year of peak exports of oil prior to the war. Close to 28 percent of that year's production of oil--428,000 barrels per day--was exported.[30]

The timely discoveries of new oil fields in Bashkir SSR, laying the foundation for the Volga-Urals producing region, prompted construction of the first refineries in the eastern part of the USSR. These were completed during the second five-year plan (1933-1937) at Ufa and Ishimbay.[31] Other refineries were built at Odessa, Moscow, Saratov, and Khabarovsk prior to World War II. However, they accounted for only a small share of the total refining capacity at the beginning of World War II. In 1940 the southern regions of USSR accounted for approximately 80 percent of the refining capacity[32] (mainly at Baku and at Groznyi) while they were responsible for only 41 percent of consumption of refined products. The southern regions were still the main producing area and had a 98 percent share of the total production of crude.

During World War II, both the oil producing and the oil refining industry suffered setbacks because of disruptions of production at the Baku and Groznyi fields, and it took until 1949 for production to reach pre-war levels. The war, however, gave an important impetus to the development of production and refining in the Volga-Urals region. By 1950 the share of crude production falling to this area was close to 29 percent of the total.[33]

With the decision of the 20th Party Congress in 1956 to basically alter the fuels balance of the Soviet economy from a predominantly coal base to oil and gas, capital investments were dramatically increased in these industries, and the rate of growth in both the production of oil and refining increased rapidly during the seven-year plan (1959-1965). Gosplan (the State Planning Committee) had recognized the need for more rational investments in the economy, based, at least partly, on rational

economic grounds rather than strictly political considerations; Gosplan directed the fuels economy to lessen the reliance on the cost-intensive coal industry.

The decision to expand the chemical industry and start the petrochemical industry during this period affected the refining industry in fundamental ways. The need for petrochemical feedstocks, new demands on gasoline and diesel fuels for the growing pool of internal combustion engines, and the deterioration of crude quality necessitated introduction of secondary processing on large scale. Whereas in 1955 secondary processing was dependent almost exclusively on thermal cracking, accounting for 98 percent of all secondary processing and constituting 48 percent of primary distillation,[34] by 1965 catalytic cracking, catalytic reforming, hydrotreating, and coking accounted for an aggregate figure of 14 percent of primary distillation.[35]

New complexes combining crude refining, gas processing, and petrochemical plants were built during this period (Novo-Kuibyishev, Novo-Ufimskiy and others). The attempts to meet new demands for diesel fuel and gasoline were not met, and as a consequence, the quality of gasoline and diesel fuel suffered.[36] The rapidly increased pool of internal combustion engines fueled by diesel oil created a condition of diesel oil shortages in the early 1960s. To alleviate the supply squeeze, gasoline fractions were used with diesel fuel, and the quality of motor fuels was allowed to deteriorate.

To alleviate the problem of the seeming imbalance between diesel fuel and gasoline supplies and their deteriorating quality, the Soviet planners' primary goals for the eight five-year plan (1966-1970) were the improvement of quality of light fractions, and the attainment of higher production levels of high octane gasolines.* This prospect

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* High octane gasoline in the USSR is gasoline with motor octane number of 72 or more. In 1965 the bulk of gasoline had a motor octane number between 60 and 65.

meant greatly increased capacity for secondary processing of crude, but the construction schedules for increasing capacity were not fulfilled, as in the previous plan, and the allocation of resources to secondary processing detracted from efforts to increase the primary capacity of the refineries. The lags in construction of refining facilities in the USSR are well-publicized, and it has been reported that up to ten years are required to build a refinery. Apparently, to reduce the imbalance between gasoline and diesel fuel supplies, a shift has been made to production of gasoline engines in greater quantities.

Most of the gains in primary refinery capacity in the past five-year plan period have been made at the expense of higher utilization of existing facilities.[37] The refining capacity expansion has not kept up with the rate of crude oil production gains, and the current five-year plan calls for major increases in primary capacity through modernization and the expansion of existing refineries and construction of new refineries.

The charge of crude to refineries in the USSR amounted to approximately 271 million metric tons (5.4 million U.S. barrels per calendar day) in 1970. A plot in Figure C-14 shows the crude production and the refinery charge from 1950 to 1971.

3. Location of Soviet Refineries and Refining Capacity

There are now over 50 refineries in the USSR, ten of which have been under construction during the current five-year plan, scattered over the country in a rather uneven fashion.

Prior to World War II the refining industry was concentrated in the Caucasus region, and the only sizable refinery existing outside this area was the one at Ufa. The war years brought with them the necessity of installing new refineries in the newly developed producing

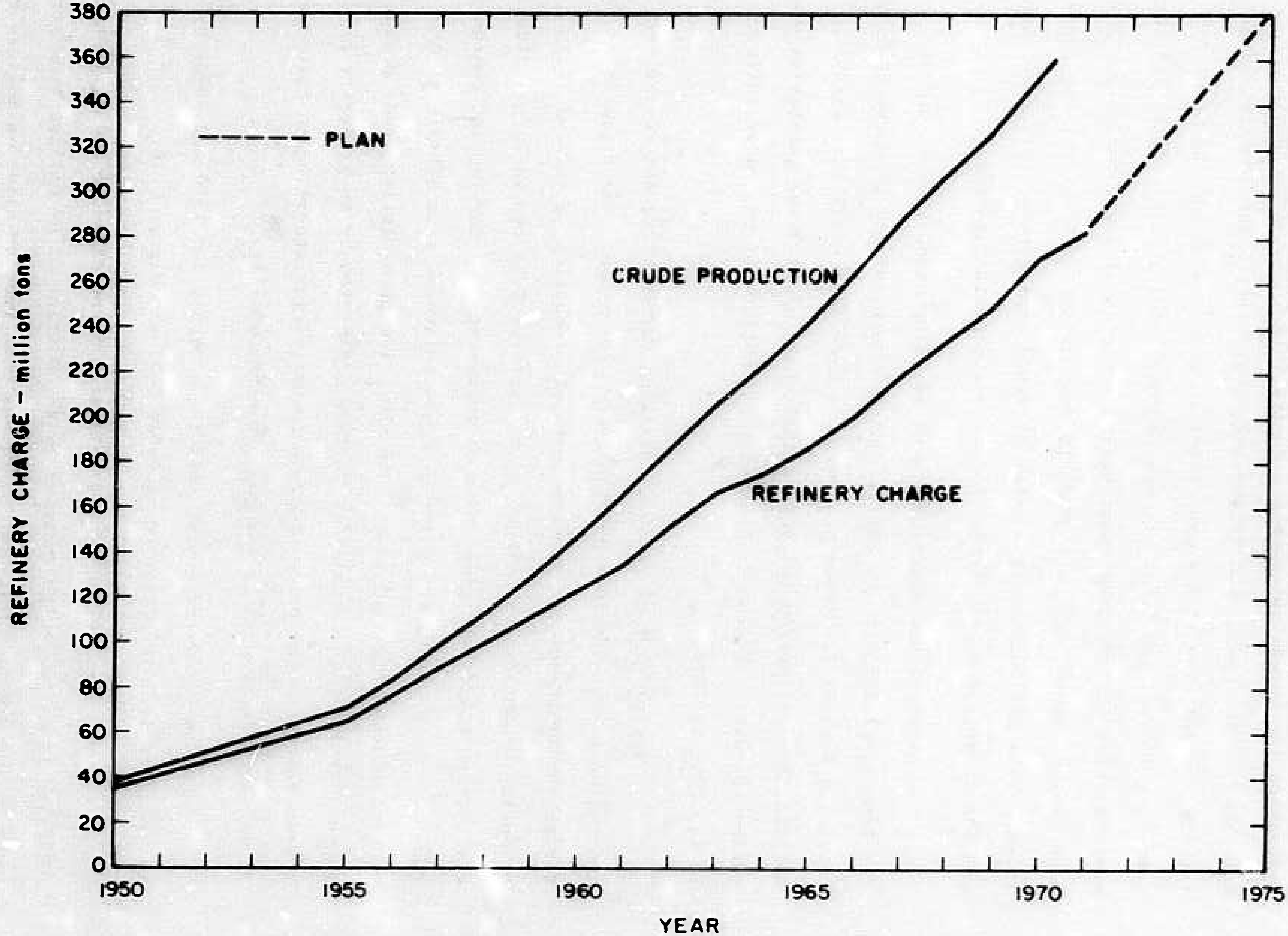

Figure C-14

CRUDE PRODUCTION AND REFINERY CHARGE IN THE USSR, 1950-1971

regions of the Volga-Urals basin. During this time the refineries at Kuibyshev, Orsk, Guriev and Krasnovodsk were built. The immediate postwar era saw addition of new capacities in what had become the major oil producing area of the USSR. It was not until the middle fifties and the early sixties that serious construction of refineries was begun in European regions having high oil products demands but lacking refining facilities. This period was also marked by rapid expansion of oil production and the extension of the crude oil and gas pipeline systems.

Although the distribution of refining capacities at present is far from ideal relative to the overall economics of oil products utilization, the current five-year plan will attempt to rectify this situation by building new refineries in regions that must import large quantities of refined product. Figure C-15 shows the locations of the major refineries in the USSR in 1970.

The problem of rational planning for locating new refineries is aggravated by the lopsided pricing system for crude. The price of crude varies in direct relation to the costs of production by various regional producing organizations. These price differentials can be larger within a producing region than the costs of transport to a far-removed consuming region. For example, the price of crude delivered from Siberia to the central regions might be lower than the price of a similar crude produced in the Ukraine. The problem is further aggravated by an arbitrary pricing system that sets the price of crude to refineries according to their regional location and without regard to crude quality.[38]

The estimated Soviet refining capacity for 1970 and 1975, by economic region, is presented in Table C-37 and Figure C-16.

The total capacity was estimated to be close to 300 million in 1970 and is estimated to increase by an addition of 84 million tons per year by the end of 1975. The major new construction sites as well as expansions are shown in Table C-38 and Figure C-17.

Figure C-15

MAJOR REFINERY SITES IN THE USSR - 1970

Table C-37

ESTIMATED REFINING CAPACITY OF THE USSR
BY ECONOMIC REGIONS

Economic Region	Capacity (million metric tons/year) 1970	1975*
1. Northwestern	10	16
2. Central	20	20
3. Volga-Viyatskii	14	14
4. Central-Chernozemnii	2	2
5. Volga	76	82
6. North Caucasus	24	24
7. Urals	28	28
8. Western Siberia	18	20
9. Eastern Siberia	12	16
10. Far East	14	16
11. Baltic	2	4
12. Belorussia	6	12
13. Southwestern 14. Donetsko-Pridneprovskii 15. Southern	25	57
16. Trans-Caucasus	28	28
17. Kazakhstan	8	20
18. Central Asia	14	26
M. Moldavia	0	0
Total for USSR	301	385

* Estimate.

Figure C-16
REGIONAL REFINING CAPACITY IN THE USSR IN 1970, WITH 1975 ESTIMATE
(Million Tons)

Table C-38

MAJOR REFINERY CONSTRUCTION IN THE USSR (1971-1975)
(Primary Capacity)

Economic Region	Refinery (City)	Comments	Estimated Additional Capacity by 1975 (million tons/year)
1. Northwestern	Kirishi	Expansion	6
11. Baltic	Mazheikiyai	New	2
12. Belorussia	Mozyr	New	6
14. Donetsko-Pridneprovskii (Ukraine)	Kremenchug	Expansion	12
	Lysichansk	New	18
17. Kazakhstan	Pavlodar	Expansion	6
	Chimkent	New	6
18. Central Asia	Chardzhou	New	6
Subtotal			62
Others			22
Total			84

Figure C-17

MAJOR CONSTRUCTION SITES OF REFINERIES IN THE USSR -- 1971-1975

The estimated refining capacity for the USSR as a whole up to 1990 is presented in Table C-39. The estimates for future expansion are based on evaluation of historical performance of the construction enterprises, or perhaps more correctly, the lack of performance. However, the capability to shift emphasis on capital resources allocation should not be underestimated, and in view of the importance of the refining industry to economic development in the USSR, a fairly substantial growth rate has been assumed for the period 1975 to 1990. It was assumed that a 5 percent growth in refining capacity should be realistic for the period 1975 to 1980, and a 4 percent growth for 1980 to 1990. These rates are probably within the capability of the Soviet construction industry in particular, since they depend on Soviet ability to incorporate secondary refining capacity.

Table C-39

ESTIMATED REFINING CAPACITY OF THE USSR TO 1990

Year	Capacity (million metric tons/year)	Plan
1950	40.3	
1955	75.9	
1960	145.5	
1965	220.1	
1970	300.6	
1975	385*	421
1980	491†	
1990	727‡	

* Assuming 84.5 million tons additional capacity installed 1975/1970.

† Assuming annual growth rate of 5 percent for 1980/1975.

‡ Assuming annual growth rate of 4 percent for 1990/1980.

4. Refinery Product Output

a. Product Slate

As a contrast to the U.S. refineries, the Soviet refinery product slate is characterized by an abundance of mid-distillates represented by kerosene and diesel fuel as well as a higher proportion of fuel oils. This product slate closely resembles that of Western Europe, with the possible exception of kerosene production. Kerosene and jet fuel production account for approximately 14 percent of the total refinery product in the USSR, while accounting for only 4 percent in Western Europe. This difference can be partly explained by a still sizable market for illuminating kerosene in the USSR.

Table C-40 shows the refinery product slate, expressed as a percentage of total refinery product.* Examination of this product slate in the post-World War II period will reveal significant shifts in the relative amounts of the various products. These can be explained by shifts in demand patterns as the industrial and agricultural centers shifted their traditional fuels in the first case from coal to oil and gas, and in the latter, from gasoline to diesel.

In spite of known large reserves of both natural gas and oil, the shift to the use of these fuels was not begun until the middle 1950s. Long before then, it was obvious to some of the Soviet economists that the economically sensible course was a shift from the use of coal to the use of oil and gas. However, perhaps because of economic decisions based on an apparent archaic price structure, because of political decisions to save these resources for export, or because of the influence

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* Actual refinery runs and product output are regarded as a state secret in the USSR. See later section on Refinery Product Methodology.

Table C-40

REFINERY PRODUCT SLATE IN THE USSR

(Percent of Total Product)

Product	Year 1950	1955	1958	1965	1966	1968	1969	1970	1975* (Plan)
Gasoline	17.2%	19.1	22.0	17.3	17.2	15.9	16.6	16.5	16.1%
Kerosene	20.6	26.5	21.5	13.0				13.6	16.8†
Diesel fuel	7.2	16.0	22.1	24.6	24.7	24.6	24.1	23.1	20.7
Lube oil	4.8	4.0	3.0	2.6				2.5	2.5‡
Residual fuel oil and others	50.2	34.4	31.4	42.5				44.3	43.9§

* Obtained from planned production indices of the official Soviet five-year plan, 1975/1971.

† Calculated by difference after subtracting estimated planned production of other products from the total refinery product. This may be high and probably should be around 14 percent.

‡ Assumed that percentage of lube oil output will not change from that of 1970.

§ The Soviet index for production of residual fuel is given for furnace grade fuel oil and was assumed to represent all fuel oils. This number may actually be higher and that of kerosene lower. (see note †).

of the powerfully entrenched coal ministry, the final decision to shift the fuel base was not made until Khrushchev's coming to power. By the beginning of the seven-year plan, 1959-1965, the Soviets were completely committed to this new policy.[39*] The new awareness that use of fuels should be based on more rational economic grounds than before led to changes in various sectors. The construction and changeover to diesel engines was begun in agriculture and railroad transport. This fact is reflected in the rapid growth of the share of diesel fuel production in the total refinery slate. The production of diesel engines reached such proportions that there were shortages of diesel fuels by the mid-1960s, requiring the users to blend lighter fractions. It had also become apparent by that time that the use of higher compression gasoline engines might be as economical because of their inherent efficiency. Higher compression engines provided a way out of the dilemma that the refiners faced in providing enough diesel fuel, and at the same time, disposing of the gasoline fraction. The balance was then struck between the production of diesel fuel and the production of gasoline. Of course, the requirements of the higher compression gasoline engines were responsible, in part, for the large emphasis placed on building up the secondary refining capacity in the eighth five-year plan (1966-1970).

At the same time that higher demands were made on refiners to provide diesel fuel, similar demands were made on fuel oils by the electric power industry. The importance of the power industry in the use of residual fuels is reflected in the total share of residuals output, which was 44 percent of the total refinery output in 1970. The importance of fuel oil to the Soviet economy is also reflected in the change in emphasis for the product slate in the current five-year plan.

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* Campbell, reference 39, gives a comprehensive discussion of this period in economic planning.

The production of residual fuel is to keep the same share as it had in 1970, while the share of diesel fuel is to drop somewhat. According to discussions in current Soviet literature, the refinery slate as given for 1970 is likely to remain the same for the near future. This assumption is probably correct, considering that there are no immediate plans to change the fuels consumption patterns of the various sectors of the economy.

b. Quality of Products

The similarity of the product slate of the Soviet refineries to those of Western Europe does not extend to the quality of their products. The industry has traditionally been plagued by inadequate secondary processing capacity, particularly by lack of hydrotreating facilities, resulting in high-sulfur content of the various mid-distillates as well as of the residual fuel oils. The problem arises from the high-sulfur content of the Soviet crudes.*

In the USSR, the crudes are classified as low sulfur, those containing less than 0.5 percent by weight (wt%) sulfur; sulfurous, those containing 0.5 to 2.0 wt% sulfur; and highly sulfurous, those containing more than 2 wt% sulfur. In general, crudes coming from the old producing regions in the Caucasus tended to be low sulfur, while those coming from the newer Volga-Urals basin tend to have high-sulfur contents. Those of the Western Siberia basin tend to fall into the intermediate classification. The sulfur contents of some of the important crudes are given in Table C-41. As an example of the amounts of sulfur going to refineries, Table C-42 gives the sulfur content of crudes delivered to refineries in the period 1965-1967.

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* A discussion of the salt content of crude as it relates to refining is given in a later section on crude preparation (desalting).

Table C-41

SULFUR CONTENT OF SOME SOVIET CRUDES BY REGION

Crude Oil Field	Sulfur Content (weight percent)
Caucasus and Caspian basin	
Bibi-Eibat (Baku)	0.18%
Kotur-Tepe (Turkmen SSR)	0.27
Zhetybay (Kazabh SSR)	0.2
Volga-Urals basin	
Arlansk (Bashkin ASSR)	2.84
Romashkino (Tatar ASSR)	1.62
Tuymazy (Bashkin ASSR)	1.47
Western Siberia	
Ust-Balyk	1.77
Samotlor	0.92

Table C-42

SULFUR CONTENT OF CRUDES DELIVERED TO SOVIET REFINERIES
(Percent of Total)

Year	Less Than 0.5 wt%	0.5 wt% to 2.0 wt%	Over 2 wt%
1965	25.8%	64.6%	9.6%
1966	25.4	64.4	10.2
1967	24.3	64.9	10.8

Source: Khimia i tekhnologia topliv i masel, No. 1, p. 34, 1970.

It can be seen from Table C-41 that the major portion of the crude reaching the refineries falls into the category of sulfurous. The quality of the mid-distillates produced there, of course, reflects this situation.

c. Diesel Fuel

The bulk of Soviet diesel fuel produced in 1965 contained up to 1 wt% sulfur.[35] This situation has been improved considerably with the expansion of hydrotreating. The low-sulfur diesel fuel production, which by Soviet standards contains less than 0.2 wt% sulfur, has increased from 39 percent of total diesel fuel production in 1965[40] to 55 percent in 1968[41] and was 80 percent in 1970 (reference 37). Problems still remain in meeting the sulfur specifications set by Soviet standards. Corrosion still plagues the users of Soviet diesel fuels, and the lube oil inhibitors are produced in insufficient quantities to keep corrosion under control.

If the extent of discussion in Soviet literature about production of special grades of fuels for the north are any indication, then there seems to be a shortage of diesel fuel for the Arctic. Soviet diesel fuels are classified according to end use. The first general classification is for use of high speed diesels. It contains general automotive fuels of the summer and winter grades, with the Soviet designation DZ and DL and the Arctic grades A and AZ, as well as the special grades DS and S. The other two general types are the medium and slow speed grades with the designation DT and DM, and the fuels for diesel locomotives and marine engines with the designations TZ and TL. The first is the winter grade and the latter, the summer grade.

With the emphasis on the development of the resources of oil and gas in the north, the demands for the winter and Arctic grades

of gasoline and diesel fuel of the appropriate quality have apparently not been met. The difficulty arises in the lack of processing and treating facilities to overcome the conflicting requirements of meeting the standards for the solidification point of diesel fuels and the cetane number. The conflict stems from the fact that if the specification for the solidification point of -60°C is adhered to, then the long chain paraffinic content has to be kept low by dewaxing operations. However, this lowers the cetane number of the fuel to unacceptably low levels. The cetane number for Arctic grade fuels has to be kept no lower than 40 to 50 for adequate burning in diesel engines. The cetane number can be maintained also by inclusion of aromatics with substituted long chain paraffins; however, this option is not really open to the Soviets because of the predominantly paraffinic nature of their crudes.

Experimentation is now going on with the use of the so-called "wide cut fraction," where 20 to 25 percent of gasoline fraction is added to diesel fuels to overcome the solidification point problem. This addition seems to offer some promise of success, according to Soviet investigators.

d. Fuel Oils

The sulfur problem is further complicated in the residual fuel oil fractions, much of which is burned in the industrial boilers and furnaces, including the electric power industry, but does not meet sulfur content specifications.

Soviet residual fuels fall into six classifications: two grades of bunker fuels, q_5 and q_{12}; three grades of furnace and boiler fuels, grades 40, 100, and 200; and a grade of open-hearth furnace fuel, MP. The numbers refer to viscosity indices, the higher numbers having correspondingly higher viscosities. The open-hearth furnace fuel, grade MP, corresoonds closely to the grades 40 and 100 but contains less sulfur.

The viscosity of U.S. No. 6 fuel oil corresponds closely to the Soviet bunker fuel of grade q_{12}.

Table C-43 presents extracts from Soviet specifications for various grades of fuel oils. The actual sulfur content and ash content of grades 40 and 100 fuel oils are presented in Table C-44 by regional breakdown. These two grades account for the largest share of production of all the fuel oils.

It can be seen by comparing actual sulfur contents of the fuel oils in Table C-44 with specifications in Table C-43 that the maximum sulfur content specification of 3.5 percent has been exceeded in quite a number of producing regions in 1969. Being very aware of the impossibility of meeting these specifications, the Soviets have met the problem head-on by lowering specifications on products produced from a number of crudes and for some of the refineries. For example, the bunker fuel of grade q_{12} produced at the Ukhta refinery is allowed to have a sulfur content of up to 1.1 wt%. Fuel oils of grades 40, 100, and 200 produced from the crudes of the Arlansk-Chekmagush, Sernovodsk, and Buguslansk fields are allowed a sulfur content of up to 4.3 wt%. For those fuel oils that were transported by water, the water content is allowed to go up to 5 wt%.

With the slated rapid growth of both oil production and refining, it is unlikely that this situation is going to improve significantly, particularly if crudes from such fields as the Ust-Balyk (Western Siberia) are going to feed the local refineries. It appears that a great part of the Samotlor production, which has a considerably lower sulfur content than the Ust-Balyk field, is slated for export to Western and Eastern Europe.

Table C-43

FUEL OIL SPECIFICATIONS IN THE USSR

	Fuel Oil Grade*					
	"φ5"	"φ12"	"40"	"100"	"200"	"MP"
Ash content (percent)	<0.1	<0.1	<0.15	<0.15	<0.3	<0.3
Water content (percent)	<1.0	<1.0	<2.0	<2.0	<1.0	<1.0
Sulfur content† (percent)	<2.0	<0.8	<0.5 <2.0 <3.5	→ → →	→ → →	<0.5 <1.5
Flash point, °C						
Open cup			90	110	140	110
Closed cup	80	90				

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* Grade "40" fuel oil is used in small boilers, as fuel for marine boilers and industrial furnaces. Grade "100" is usually used in large stationary boilers, while grade "200" is supplied exclusively by pipelines from refineries to large industrial users.

† The furnace and boiler grade fuel oils are also classified according to their sulfur content. The highest sulfur content permitted is 3.5 percent by weight. Exceptions are made, however, depending on the crude processed, and seem to be a rule rather than the exception.

Source: M. B. Ravich, Toplivo i effectivnost' ego ispolzovaniya (Fuel and the Efficiency of Its Use), Pub. "Nauka," p. 215, (Moscow 1971).

Table C-44

FUEL OIL QUALITY IN THE USSR BY REGION
(1969)

Producing Region	Fuel Oil (grade)	Sulfur Content (weight percent)	Ash Content* (weight percent)
Center	40	1.4 - 2.7	0.03 - 0.07
	100	1.9 - 3.9	0.04 - 0.12
Caucasus	40	0.3 - 0.4	0.03 - 0.19
	100	0.3 - 0.5	0.03 - 0.22
Volga	40	0.4 - 4.1	0.03 - 0.13
	100	0.4 - 4.2	0.06 - 0.14
Urals	40	1.6 - 3.5	0.05 - 0.13
	100	1.6 - 3.9	0.06 - 0.13
Kazakh SSR	100	3.5	0.14
Siberia	40	2.2 - 2.6	0.04 - 0.12
	100	2.3 - 2.6	0.04 - 0.12
Far East	40	0.4 - 3.7	0.02 - 0.04

* Dry basis.

Source: I. I. Matveeva, Energeticheskoe toplivo (Fuels), Vol. 3, Pub. "Energia," p. 108 (Moscow 1972)

e. Gasoline

Production of high compression gasoline engines in the last few years has raised the demand for high octane gasoline. The situation for production of these gasolines has improved dramatically in the last few years.

At present, the Soviets are producing five grades of motor gasoline: A-66, A-72, A-76, AI-93, and AI-98. The numbers in the first three grades refer to the motor octane ratings, and the last two, to the research grade octane numbers. The last three grades are manufactured by addition of TEL (tetraethyl lead) to the first two, in quantities

varying from 0.41 to 0.82 grams/kilogram. In the mid-1950s, two other grades, A-56 and A-60, have been produced, but have now been discontinued. The bulk of gasoline produced in the 1950s and the early 1960s had an octane rating of about 60. In other words, almost all gasoline produced was of grade A-66. The production of "high octane" gasolines is given in Table C-45. "High octane" gasoline seems to be defined as grade A-72 or higher.

Table C-45

USSR PRODUCTION OF AUTO GASOLINES
OF GRADES A-72 OR HIGHER
(Percent of Total Auto Gasoline)

Year	Auto Gasolines of Motor Octane Rating 72 or Higher
1965	23
1966	25
1968	40
1969	45
1970	50

Sources: Khimia i tekhnologia topliv i masel, No. 11, 1966, p. 1; No. 1, 1969, p. 1; No. 1, 1970, p. 1; and No. 1, 1971, p. 2.

It is very likely that the octane rating of gasoline is going to keep growing in the future. This conclusion is based on the indications that gasoline production will not grow as rapidly as the production of fuel oil (Figure C-18). This slower rate should allow the introduction of secondary refining at a rate sufficient for improved gasoline quality.

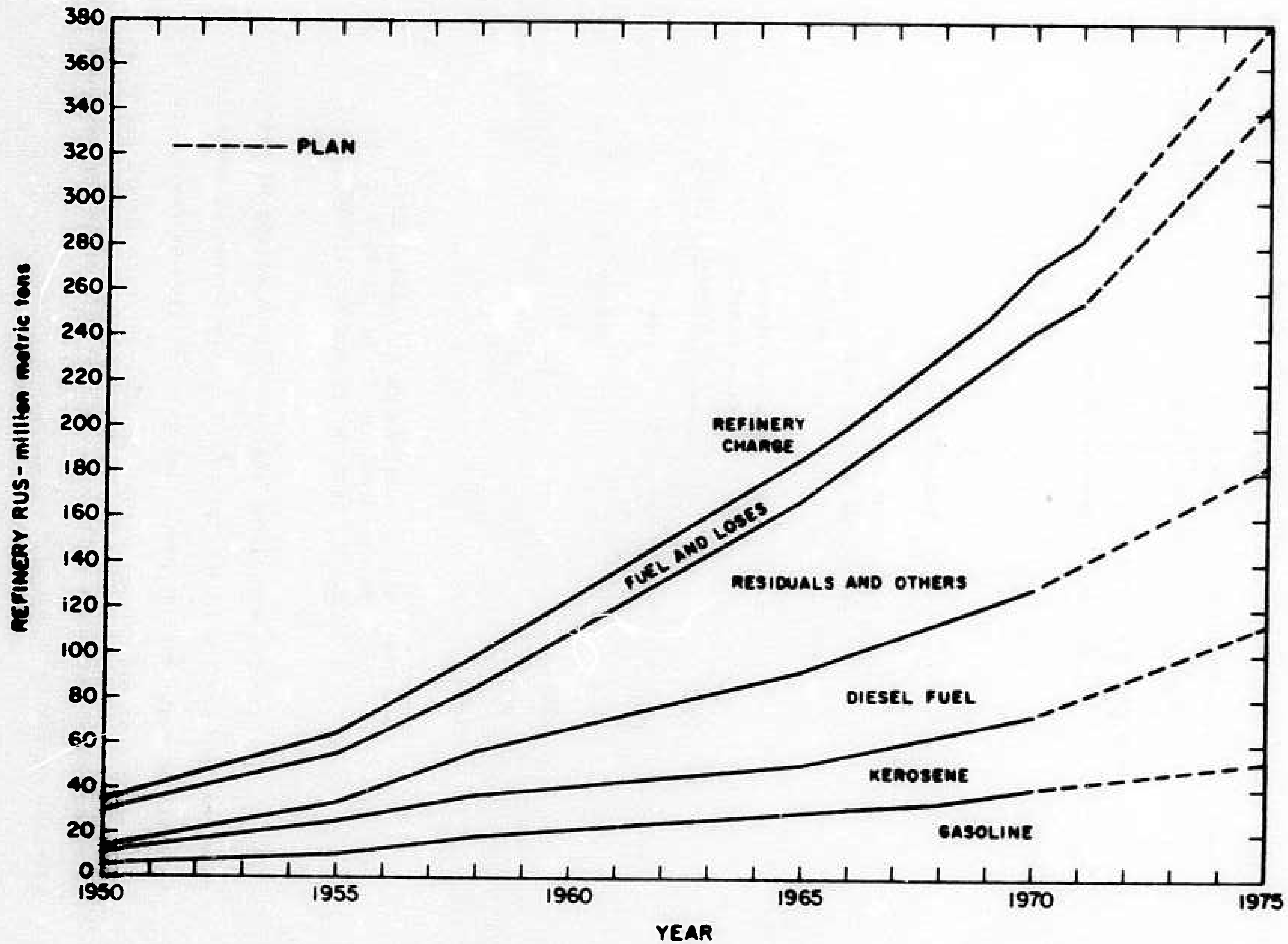

Figure C-18

APPARENT REFINERY RUNS IN THE USSR

5. Types of Oil Refineries in the USSR

a. Sizes

The refineries in the USSR are characterized by standardized units of a given throughput and design. During reconstruction of the industry after World War II, the standard size of the refinery was 500-600 thousand tons per year (approximately 10,000 barrels per day). By the late 1950s and early 1960s, these standard sizes grew to 40 to 50 thousand barrels per day, and by 1966 the standard size of the refinery grew to 120,000 barrels per day (6 million tons per year). For intermediate capacities, the refineries are usually built up to the design capacities by combination of smaller standard units. This approach puts the least strain on constructors of equipment who are, as a rule, overcommitted, overextended, and generally unable to meet construction schedules of the refinery industry. According to the report of Gosplan on the current five-year plan (1971-1975), the average size of newly installed primary distillation units will be 5.2 million tons per year (104,000 barrels per day) compared with an average unit of 3.2 million tons per year (64,000 barrels per day), built during the 1966-1970 period. The Soviet planners are currently considering construction of 9 and 12 million ton per year refineries. It is rather doubtful, however, that the latter size is realistic for the near term projects, considering the difficulties encountered by the construction industry in meeting the refinery capacity goals. These larger refineries were planned and discussed during the construction of the seven-year plan (1958-1965) but are no closer to realization now than they were at that time. In fact, the plans for primary distillation capacity growth as envisioned in the official Soviet plans have not been met either in the last five-year plan (1966-1970) or the previous seven-year plan (1959-1965), as can be seen in Table C-46.

Table C-46

GROWTH OF PRIMARY REFINERY CAPACITY IN THE USSR
(Planned and Actual)

Planning Period	Official Planned Growth Index	Actual Growth Index*
1959-1965	2.0 plus	1.9
1966-1970	1.7	1.44
1971-1975	1.4†	1.3‡

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* These figures are based on our estimates of refinery charge and do not necessarily reflect the installed capacity. There are statements in Soviet literature that the 1970/1965 growth in installed capacity was close to 1.38. It is obvious from this figure and other statements that the refineries were operating at throughputs higher than the accepted Soviet practice of 85 percent of design capacity.

† According to industry publications in 1970, this figure was initially 1.5 in the official final version of the report on the five-year plan.

‡ SRI projection.

b. Refinery Schemes

Besides size standardization, the Soviet refineries tend to fall into four main standard categories according to the predominant crude they process or the final desired product. The main type is the one geared to fuel oil production. The schematic representation of main processing steps in this type is presented in Figure C-19. No vacuum distillation takes place on fractions with boiling points above those of the straight run, atmospherically distilled diesel oil fractions. A small portion of the resulting residual oil is vacuum distilled for bitumen production, and its distillate is blended back with the main fuel oil

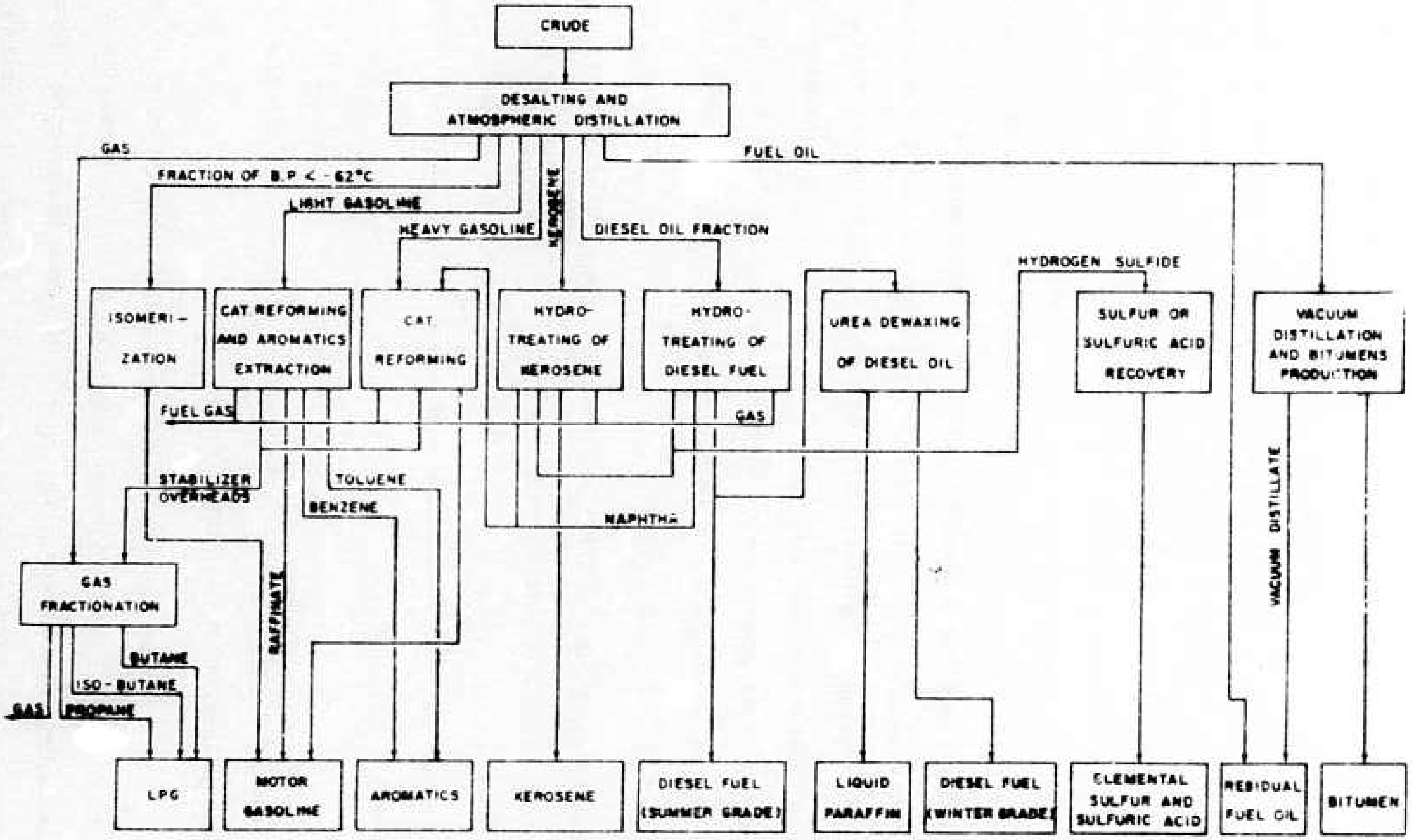


Figure C-19

HIGH SULFUR CRUDE PROCESSING - FUEL OIL PRODUCTION SCHEME

stream. The lighter fractions may undergo secondary processing, such as is shown in Figure C-19, for upgrading the gasolines to higher octane ratings through isomerization, catalytic reforming, and in the case of high-sulfur crudes, hydrotreating of the kerosene and diesel fuel fractions.

The second general scheme is one for production of light fractions, particularly motor gasolines and diesel fuels. This one is shown schematically in Figure C-20. Here, the standard units include vacuum distillation, with the vacuum column distillates undergoing catalytic cracking, and the residual tars, coking. The light cat-cracked fractions are hydrotreated and are blended back with the straight run gasoline fractions for subsequent catalytic reforming, while the heavier fractions undergo gas oils extraction, with the raffinate being blended into the residual fuel oil. The gas fractions from cat-cracking may undergo alkylation and polymerization for blending into motor gasolines. As in the first scheme, the straight run lighter fractions undergo secondary processing such as catalytic reforming and hydrotreating.

The third refining scheme is used mainly for production of lubricating oils. Here, the various distillates from the vacuum unit undergo selective oil processing steps, such as dewaxing, hydrofining, and percolation (Figure C-21). The light distillates from the atmospheric column are again processed as in schemes 1 and 2 (Figures C-19 and C-20, respectively).

The fourth scheme is that employed in construction of the refinery/chemical industry complexes. An idealized version of such a scheme is presented in Figure C-22.

The above schemes are rather comparable to those practiced in the United States and Western Europe, with the exception of the extent of secondary processing. The amount of crude undergoing secondary processing in the USSR is relatively low and reflects the emphasis on

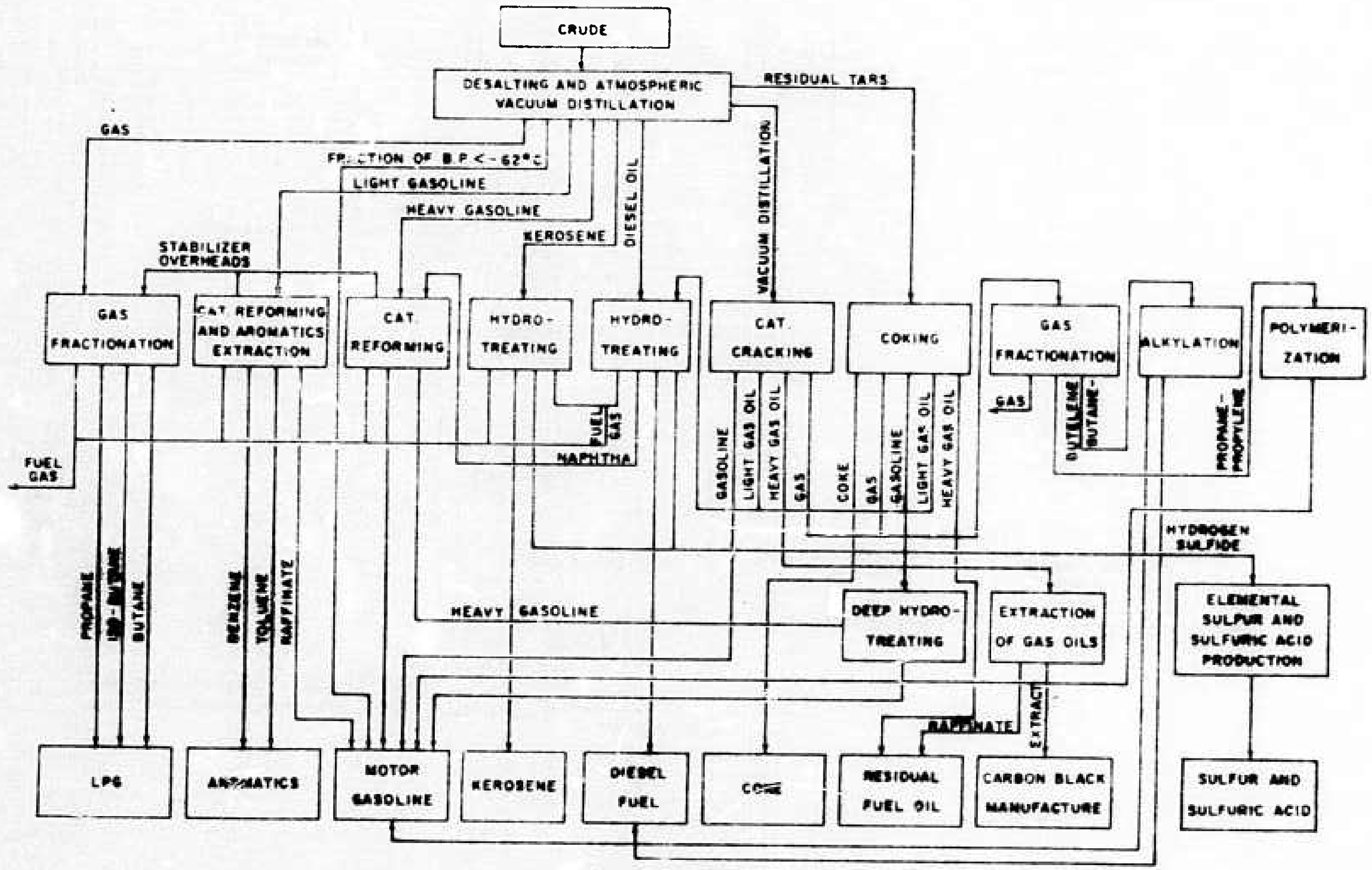


Figure C-20
HIGH SULFUR CRUDE PROCESSING – HIGH MOTOR FUELS PRODUCTION SCHEME

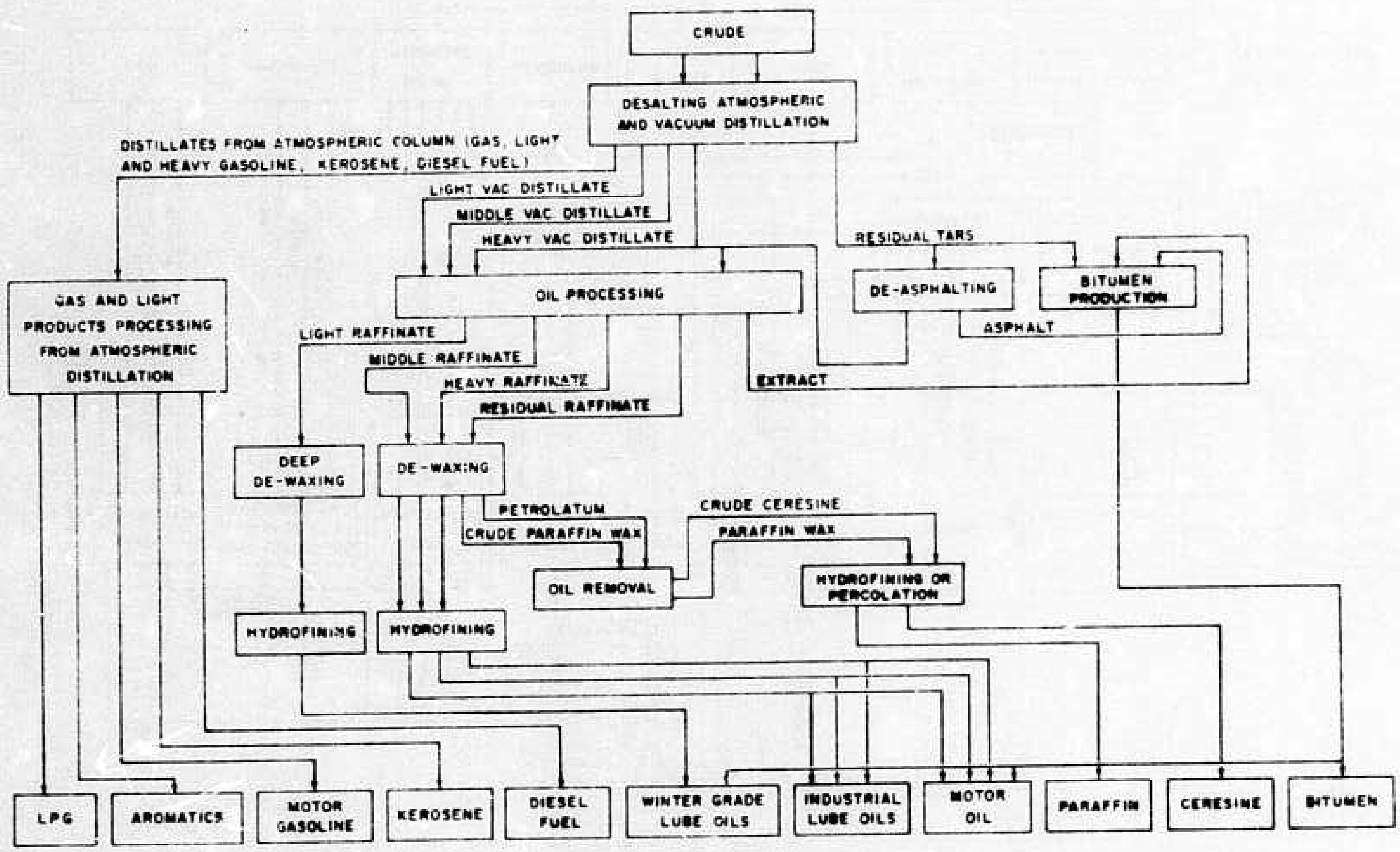


Figure C-21

HIGH SULFUR CRUDE PROCESSING – LUBRICANTS PRODUCTION SCHEME

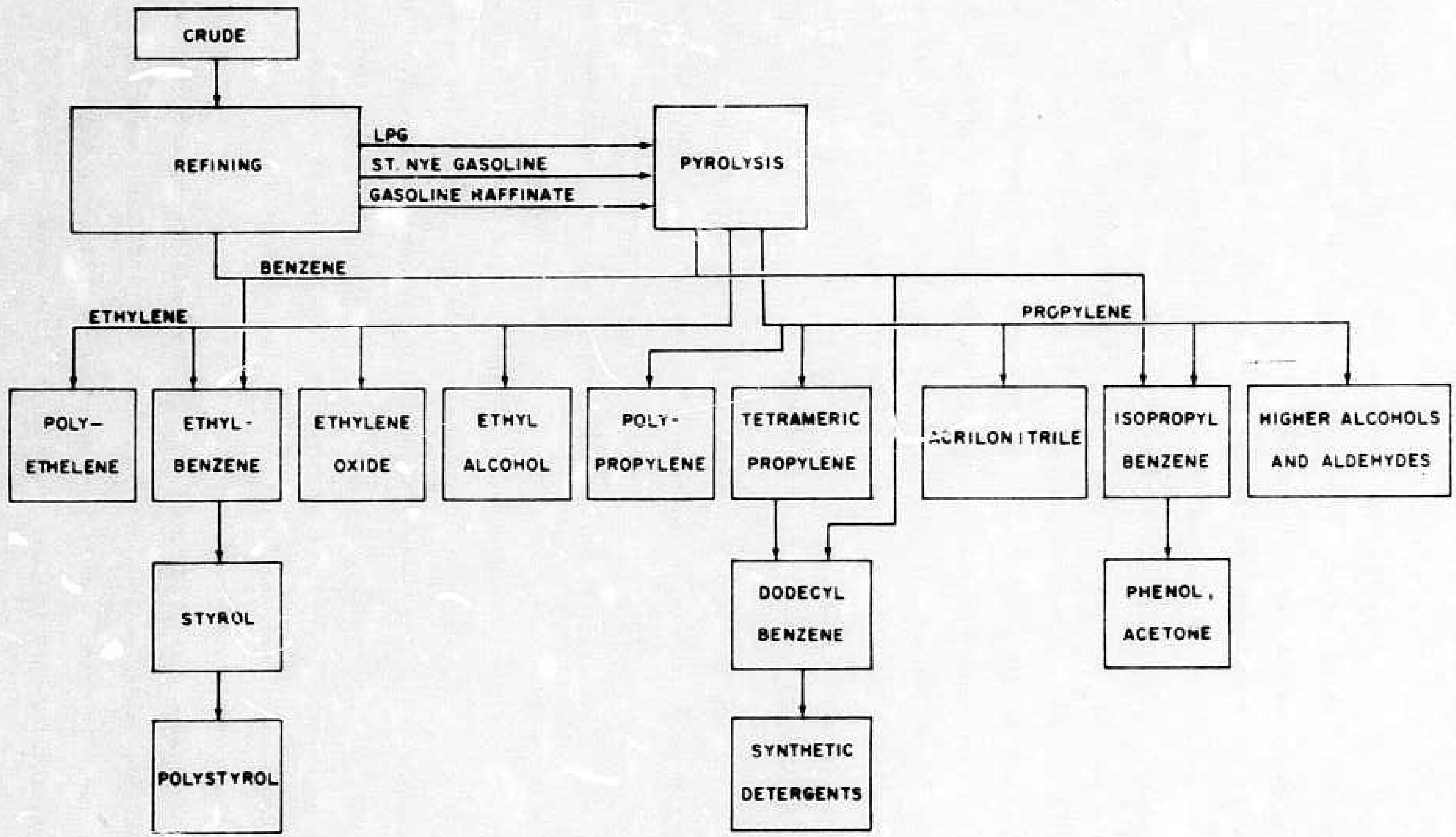


Figure C-22

SCHEMATIC OF A REFINERY – PETROCHEMICALS COMPLEX

production of fuel oil rather than gasoline (the reverse of the situation in the United States). These are, of course, the latest adaptation of refinery technology in the USSR and reflect the schemes of design that are used in the most recent refineries, either built or under construction. The extent of integration of the latest technology, as represented by secondary processing in the above flow schemes, is still very low. This situation may be seen in Table C-47, where the estimated annual amounts of charge to processes such as catalytic cracking, reforming, and hydrotreating are given for a few selected years. Thermal cracking is still a very important process in relation to others, in spite of the fact that no new thermal cracking facilities are being built or planned. In fact, some of the older thermal crackers are being converted to primary distillation, according to Soviet sources,[42] to achieve their goals in primary capacity.

During the 1966-1970 plan, great emphasis was placed on expanding secondary refining facilities. This expansion was spurred by development of new gasoline engines demanding better grades of gasoline and also by the necessity to install hydrotreating facilities to handle the ever increasing supply of high-sulfur crudes to refineries. Catalytic reforming, which is used to upgrade the gasoline octane number, is also the chief source of cheap hydrogen for hydrotreating operations. The plans for expansion of facilities for catalytic cracking and hydrotreating were nearly met; however, those for expansion of catalytic reforming were grossly underfilled, as can be seen from Table C-47. It is also obvious from discussions in Soviet literature that the pressure on the industry to expand secondary processing put a great strain on the industry's ability to expand primary distillation capacity. The goals for primary distillation capacity expansion were not met (see Table C-46) and shortages of fuel oil were reported[43] in 1969 in a number of regions by electric power stations, forcing them to burn crude, or in some cases, to shut down.

Table C-47

SECONDARY REFINING IN THE USSR
(Million Tons per Year)*

Process	1955	1960	1965†	1970 (plan)†	1970 (actual)‡
Thermal cracking	31.0§	45.0**	50.0**		50.0†
Catalytic cracking	0.6		9.7	17.5	15.5
Catalytic reforming	-	-	8.2	29.4	16.4
Coking			2.6	9.5	n.a.
Hydrotreating	-	-	5.6	12.2	11.2
Hydrocracking	-	-	-	2.4	-
Primary run	64.5	123.7	187.1		270.5

* This table differs significantly from the values reported in 1962 by the National Petroleum Council (National Petroleum Council, Impact of Oil Exports from the Soviet Bloc, Vol. II, p. 156, Washington, D.C., 1962). Presumably, estimates were made without access or availability of Soviet or other reliable data on Soviet performance at that time. It is evident from recent Soviet reports that the first catalytic cracking unit was not started until 1950 and the first catalytic reforming unit did not go onstream until 1962.

† Based on statements of actual and planned secondary refining expressed as percentage of primary runs; L.M. Tomashpolskii, Neft' i gaz v mirovom energeticheskom balanse 1900-2000 (Oil and Gas in the World Energy Balance 1900-2000), Pub. "Nedra," p. 126, Moscow, 1968.

‡ From Khimia i tekhnologia topliv i masel, No. 5, 1970.

§ From R.W. Campbell, The Economics of Soviet Oil and Gas, p. 169 (Johns Hopkins Press, Baltimore, Md., 1968).

** These are estimates based on growth rate of thermal cracking for the years 1953 to 1957 as reported by Campbell (see footnote § above). The 1970 estimate is based on Soviet statements that no new thermal cracking is being added presently, presumably referring to the 1966-1970 five-year plan.

The reported primary distillation gains were made by some expansion, but primarily by running the existing refineries at higher throughputs than the usually accepted practice of 85 percent of capacity. This case is another graphic example of the inability of the Soviet construction industry to meet planners' goals.

The new five-year plan, 1971-1975, puts the emphasis on construction and expansion of primary capacity, and particularly on the expansion of fuel oil production. The planners hope to keep the proportion of secondary processing to primary distillation at the same relative level as achieved in 1970. The increment in planned primary capacity is probably unrealistic, and if we assume a primary capacity equal to 91 percent of that planned for 1975, then the relationship of secondary to primary charge will probably be maintained at the same level as in 1970. The increment in growth of secondary capacity (catalytic processes) charge will then be lower than or equal to the increment achieved for secondary capacity installed between 1965 and 1970.

It is hard to predict what will happen to the relationship between secondary and primary capacities beyond 1975. It is obvious from past performance, however, that if an attempt is made to keep the growth of refining at the currently planned levels, the ability to expand catalytic processing will be limited to the maintenance of the present level. This applies, of course, only if no outside help is sought by the Soviets in supplying them with foreign technology and investment funds.

6. Refinery Product Methodology

Oil refining and oil product consumption are treated as a state secret in the USSR; therefore, the individual product statistics are not available. However, from time to time, production indices for refinery runs, as well as for selected products, are reported in various industry journals and books. From these, one can build up approximate estimates

of the product slate and quantities, if certain assumptions are made as to refinery charge quantities, product use, and losses within the refineries.

a. Refinery Charge

In this report, the methodology for arriving at the refinery charge is essentially the same as that used by Ebel,[44] Campbell,[45] and the National Petroleum Council.[46] The starting point is the annual production and trade statistics published by the Soviets.[47,48] After correcting production for net trade, we made a further correction for field use, transport losses, and the amount used to fill new pipelines. The losses in field and during transport have been assumed to be 5 percent of total production. This assumed loss is the same as that used by Campbell;[45] however, it is higher than that used by other reporters (i.e., National Petroleum Council, Ebel, CIA). We believe that this higher figure is justified because of recurring pleas in the Soviet literature to lower the crude transport losses. These losses must surely be embarassingly high. The amounts of crude used to fill new pipelines was again estimated by the method used by Campbell.[45] He used Soviet reported data for annual length of newly completed pipelines[47] and an average diameter of 20 inches. We have also been assuming that the pipelines were filled in the year that they were reported to have been installed. The amounts of crude going into storage and the amount remaining for delivery from previous years have been ignored, because it has been assumed that the amount of crude held in storage remains constant from year to year. Because of lack of precise definition in literature of this last factor, we believe that trying to make estimates of differences in storage for various years would have added an unjustifiable complication to this procedure. The results of this approach can be seen in Table C-48.

Table C-48

ESTIMATES OF APPARENT REFINERY CHARGE
(Thousand Metric Tons)

Year	Crude Production*	Exports	Imports	Field Losses	To Fill Pipelines	Apparent Refinery Charge
1946	21,746	-	9	1,087	†	20,668
1950	37,878	303	337	1,894	n.a.	34,238‡
1955	70,793	2,916	575	3,540	373	64,539
1956	83,806	3,897	1,510	4,190	190	77,039
1957	98,346	5,923	1,331	4,917	259	88,578
1958	113,216	9,093	1,079	5,661	190	99,351
1959	129,557	12,485	1,083	6,478	373	111,304
1960	147,859	17,825	1,166	7,393	100	123,707
1961	166,068	23,388	888	8,303	518	134,747
1962	186,244	26,279	496	9,312	200	150,949
1963	206,069	30,243	543	10,303	356	165,710
1964	223,603	36,691	-	11,180	500	175,232
1965	242,888	43,432	-	12,144	264	187,048
1966	265,125	50,314	-	13,256	264	201,291
1967	288,068	54,117	61	14,403	264	219,345
1968	309,150	59,216	124	15,458	589	234,011
1969	328,373	63,888	1,459	16,419	345	249,180
1970	353,039	66,800	2,516	17,652	569	270,534
1971	377,075	74,800	2,089	18,854	102	285,408

n.a. - not available.

* Crude production figures include gas condensate.

† Assumed no pipelines completed this year.

‡ Calculated; based on Soviet Index for refinery charge 1955/1950 (Reference 51).

To check the validity of these estimates, reported Soviet indices for primary refinery runs were compared, for a few spot years, to estimates of refinery charge in Table C-48. Table C-49 shows this comparison.

b. Total Refined Product and Apparent Consumption

As in the estimates of refinery charge, losses and consumption of crude and products within the refineries had to be assumed. These losses were taken to be those reported by Campbell[45] for the years 1948 to 1965 and thereafter, a total fuel usage of 6 percent and crude and product losses of 4 percent, based on refinery charge, were assumed. These figures are substantiated by reported[49] current consumption and crude and product losses of 13 percent of crude production from field through the refineries. (Our assumed total loss figure is also close to 13 percent of the original crude production.) It is clear from another statement[50] that direct crude and product losses have gone down from approximately 4.6 percent in 1952 down to 2.2 percent in 1970. If we add this difference to the 13 percent figure above for direct losses and fuel usage, we conclude that the use of Campbell's figures of 14 to 15 percent for earlier years is probably justified. Apparent consumption of total refined products is arrived at after correcting for foreign trade. The results of the above procedures can be seen in Table C-50.

c. Refined Product Slate

The refinery product slate was estimated by building on various statements in Soviet literature as to the indices of production and consumption for various products over several years.

Some key statements on consumption of kerosene and diesel fuel in 1965 allowed us to estimate the production, by correcting for foreign trade in these products (Table C-51). From these production

Table C-49

COMPARISON OF SOVIET INDICES OF REFINERY CHARGE WITH ESTIMATES IN TABLE C-48

Year	Apparent Refinery Charge (million metric tons)	Estimated Index	Soviet Reported Index	% Deviation from Soviet Index
1946	20.7	61	55[b]	+ 11.0
1950	34.2	100	100	
1955	64.5	189	189[a]	
1956	77.0	225	223[c]	+ 0.9
1957	88.6	259	256[d]	+ 1.2
1958	99.4	291	288[e]	+ 1.0
1959	111.3	325		
1960	123.7	362		
1961	134.7	394		
1962	150.9	441		
1963	165.7	485		
1964	175.2	512		
1965	187.0	547	547[f]	0.0
1966	201.3	589	584[g]	+ 0.9
1967	219.3	641		
1968	234.0	684	684[h]	0.0
1969	249.2	729	722[i]	+ 1.0
1970	270.5	791	793[j]	- 0.3
1971	285.4	835	839[k]	+ 0.5

a - 1955/1950 Index reference 51.
b - 1955/1946 Index reference 52.
c - 1956/1955 Index reference 51.
d - 1957/1946 Index reference 51.
e - 1958/1957 Index reference 53.
f - 1965/1958 Index reference 54.
g 1966/1965 Index reference 55.
h - 1968/1965 Index reference 56.
i - 1969/1965 Index reference 57.
j - 1970/1969 Index reference 58.
k - 1971/1970 Plan Index reference 59.

Table C-50

TOTAL REFINERY PRODUCT OUTPUT AND APPARENT CONSUMPTION
(Million Metric Tons)

Year	Apparent Refinery Charge	Fuel Losses †	Direct Losses †	Apparent Product Output ‡	Exports §	Imports §	Apparent Consumption
1950	34.24	3.61	1.53	29.1	0.8	2.3	30.6
1955	64.54	6.94	2.58	55.0	5.1	3.8	53.7
1956	77.04	8.10	3.08	65.9	6.2	3.[illegible]	63.5
1957	88.58	9.11	3.55	75.9	7.8	2.9	71.0
1958	99.35	9.98	3.97	85.4	9.0	3.2	79.6
1959	111.30	11.12	4.45	95.7	12.9	3.3	86.1
1960	123.71	11.89	4.95	106.9	15.4	3.2	94.7
1961	134.75	11.72	5.39	117.6	17.8	2.7	102.5
1962	150.95	11.87	6.04	133.0	19.1	2.3	116.2
1963	165.71	11.54	6.63	147.5	21.1	2.3	128.7
1964	175.23	10.51	7.01	157.7	19.9	2.1	139.9
1965	187.05	11.22	7.48	168.4	21.0	1.9	149.3
1966	201.29	12.08	8.05	181.2	23.3	1.7	159.6
1967	219.35	13.16	8.77	197.4	24.7	1.4	174.1
1968	234.01	14.04	9.36	210.6	27.0	1.1	184.7
1969	249.18	14.95	9.97	224.3	26.9	1.1	198.5
1970	270.53	16.23	10.82	243.5	29.0	1.1	215.6
1971	285.41	17.12	11.42	256.9	30.3	1.5	228.1

* From Table C-48.

† Campbell's figures were used for 1950 through 1963 (reference 45). From 1964 on, 6 percent fuel use and 4 percent direct losses were used.

‡ In view of all the assumptions made in derivation of the product quantities, it is not justified to carry more than one decimal place.

§ See reference 48.

Table C-51

SOVIET FOREIGN TRADE IN REFINED PRODUCTS
(Million Metric Tons)

Product	1950	1955	1958	1965	1966	1968	1969	1970
Gasoline								
Export	0.3	1.4	1.9	2.3*	2.7	3.4	3.3	3.5
Import	1.2	2.0	2.1	1.2*	0.9	0.7	0.6	0.4
Kerosene								
Export	0.2	0.6	0.9	1.2	1.3†	1.3	1.5	2.1
Import	0.3	0.5	0.4	0.2	0.1†	-	0.1	0.2
Diesel fuel								
Export	0.1	1.3†	3.4†	7.4	8.3†	10.1	10.0†	11.4
Import	0.3	0.6†	0.4	.2	0.2†	0.2	0.2	0.2
Lube oils								
Export	0.1	0.2†	0.3	0.3†	0.3	0.3	0.3	0.3
Import	0.1	0.1	0.1	0.2†	0.1	0.1	0.1	0.1
Residuals and others‡								
Export	0.1	1.5	2.5	9.8	10.8	11.9	11.8	11.7
Import	0.4	.5	0.2	0.1	0.4	0.1	0.1	0.2

Source: Vreshniaia torgovlia SSSR (Foreign Trade of the USSR), Pub. "Mezhduorarodnoie otnosheniya, Ministry of Foreign Trade, Mowcow. The latest year of publication is 1972.

* Obtained from United Nations sources (reference 61).

† Soviet statistics are reported to three decimal places. However, these numbers were rounded off so that net trade (Export-Import) was consistent with the original sources.

‡ Calculated as the difference in trade between all products and the sum of trade in gasoline, kerosene, diesel fuel, and lube oils.

figures and various key indices, it was then possible to reconstruct, at least for some years, the product slate.

The method can be illustrated by following the notes to Tables C-52 and C-53, which cover the production and consumption of petroleum products for several key years. The starting point is the consumption of kerosene and diesel fuel in 1965, as shown in Table C-53.

d. Crude Preparation (Water Separation and Desalting)

The problems of field crude processing plague the refiners in the USSR because of high water and salt content of delivered crude.

Primary desalting of crude takes place in the USSR in field installations of water separators. Electrostatic separators are not used in the field, as a rule, but are usually installed as part of the crude treating facilities at the refineries. There are a few exceptions, particularly in regard to crude destined for export in the Druzhba pipeline that is desalted by means of electrostatic installations in the field.[67]

A typical field water separator is shown in Figure C-23.

The crude is mixed with de-emulsification agent, is heated, and then is allowed to settle in tank E-3 for about one to three hours at a pressure of approximately 15 atmospheres. (In the 1950s and early 1960s, atmospheric systems were used with high concomitant losses of vapor.) The oil then goes to a storage tank and the water, after secondary settling in E-5, is pumped back into formation.

Until recently, extensive use was made of surface active, anionic de-emulsifiers, both in field installations as well as at the refineries. However, now the more effective nonionic types are being used. Even then, the performance of these field units is unsatisfactory.

Table C-52

APPARENT PRODUCTION OF REFINED PRODUCTS
(Million Metric Tons)

Product	1950	1955	1958	1965	1966	1968	1969	1970
Gasoline*	5.0	10.5	18.8	29.1	31.2	33.5	37.2	40.2
Kerosene†	6.0	14.6	18.4	21.9				33.1
Diesel fuel‡	2.1	8.8	18.9	41.5	44.8	51.9	54.0	56.2
Total lights	13.1	33.9	56.1	92.5				129.5§
Lube oils**	1.4	2.2	2.6	4.4				6.2
Residuals and others††	14.6	18.9	26.7	71.5				107.8
Total heavies	29.0	40.9	29.3	75.9				114.0
Total product ‡‡	29.1	55.0	85.4	168.4	181.2	210.6	224.3	243.5

Note: The sources cited below do not include calculations and inferences drawn from comparing statements and data.

* Values for gasoline from references 45, 52, 54, 55, 56, 57, 58, and 63.

† Values for kerosene from Table C-53 and references 52 and 62.

‡ Values for diesel fuel from references 52, 54, 55, 56, and 57.

§ Value for total lights in 1970 from an estimated production index published in May 1970.

** Values for lube oils from references 45, 46, 52, 65, and 66.

†† Values for residuals and others figured as the difference of all products and the sum of gasoline, kerosene, diesel fuel, and lube oils.

‡‡ Values for total product from Table C-50.

Table C-53

APPARENT CONSUMPTION OF REFINED PRODUCTS*
(Million Metric Tons)

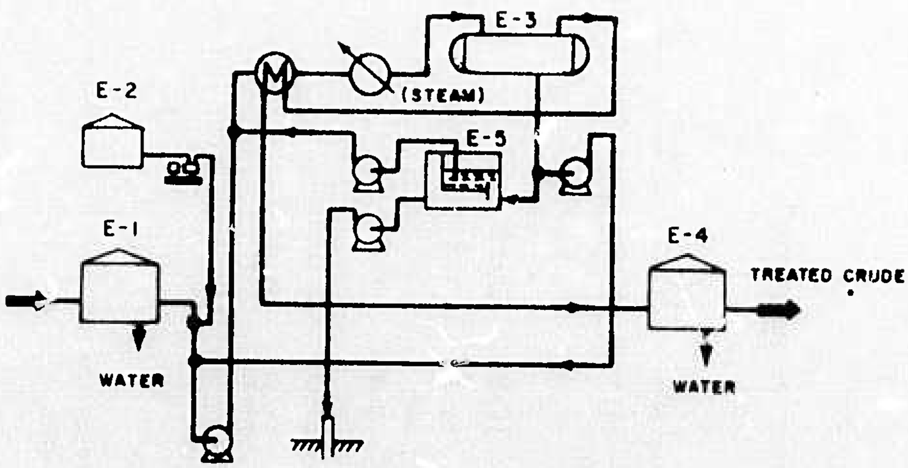
Product	1950	1955	1958	1965	1966	1968	1969	1970
Gasoline	5.9	11.1	19.0	28.0	29.4	30.8	34.5	37.1
Kerosene	6.1†	14.5	17.9	20.9‡				31.2
Diesel fuel	2.3	8.1	15.9	34.3‡	36.7	42.0	44.2	45.0
Total lights	14.3	33.7	52.8	83.2				113.3
Lube oils	1.4	2.1	2.4	4.3				6.0
Residuals and others	14.9	17.9	24.4	61.8				96.3
Total heavies	16.3	20.0	26.8	66.1				102.3
Total Product Consumption§	30.6	53.7	79.6	149.3	159.6	184.7	198.5	215.6

* Except for kerosene and diesel fuel in 1965, all consumption is obtained by correcting production figures from Table C-52 by foreign trade (Table C-51).

† From Campbell (reference 45).

‡ From statement by Brenner (reference 60) that in 1965, the consumption of diesel fuel and kerosene represented 37 percent of total products and that of kerosene 14 percent.

§ From Table C-50.



Source: Reference 67.

TANKS E-1 CRUDE RECEIVING TANK
E-2 DE-EMULSIFICATION TANK
E-3 SETTLING TANK
E-4 CRUDE PRODUCT TANK
E-5 SECONDARY WATER-OIL SEPARATOR

Figure C-23

DIAGRAM OF FIELD WATER SEPARATOR

By Soviet economic norms, the crude arriving at refineries should contain no more than 40 to 50 mg/liter of salts and less than 0.2 percent of water. Experience says otherwise. It is not uncommon to receive crude at refineries with the salt content running up to 2,000 mg/liter and water contents of up to 2 percent. The same installations are being used in the field without regard to the quality of crude produced, thus allowing wide variations in performance of these units. The oils of the Urals-Volga, for example, contain large amounts of sulfur, asphaltenes, and paraffins. The water coming up with these oils is also highly mineralized (containing 280-300 grams/liter of mineral salts). The emulsions formed in these oils are as a consequence more stable, and the water and salt content of treated crude is high. In contrast, the oils from Western Siberia have smaller quantities of the above hydrocarbons, and the salt content of water is only 12-25 grams/liter.

The lack of success in these field desalting operations is illustrated in Table C-54, which shows the water contents and salt concentrations of all crude delivered in the USSR to the refineries between 1965 and 1967.

Table C-54

SALT AND WATER CONTENT OF CRUDE DELIVERED TO REFINERIES
(Percent of Total Delivered Crude)

	Water Content			Salt Content		
	Up to 1%	1 to 2%	Over 2%	Up to 300 mg/1	300 to 1,800 mg/1	Over 1,800 mg/1
1965	46.1	80.8	23.1	22.8	26.2	51.0
1966	53.2	38.0	8.8	21.4	26.9	51.7
1967	50.6	42.5	6.9	21.3	34.0	44.7

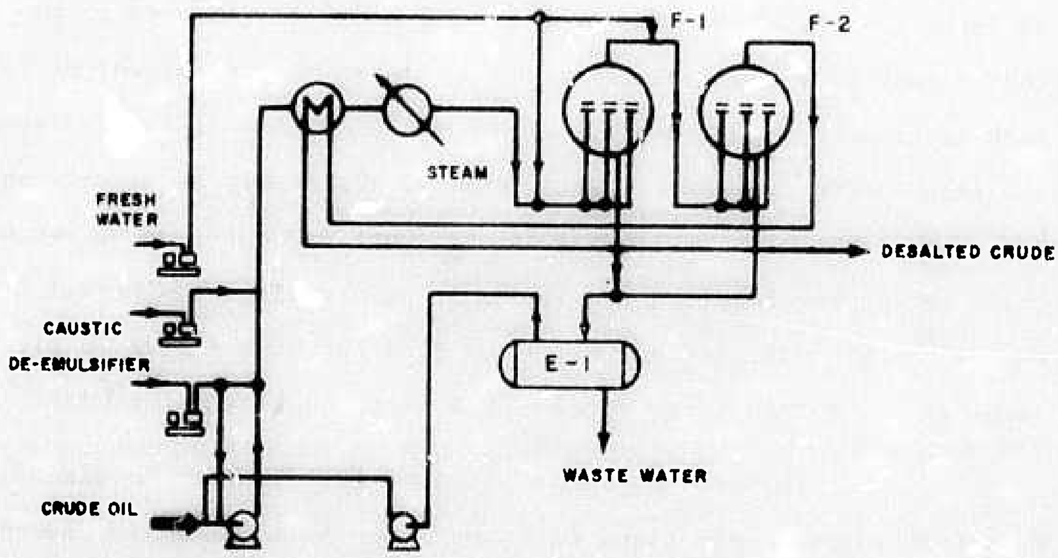
final, and often the only, desalting takes place in refineries in electrostatic desalters such as the one shown in Figure C-24.

The process flow here is simple and self-evident. Often a simple separator stage, such as in the field installations, is included in this scheme before the first electrostatic stage, F-1. Also, to conserve the use of water, fresh water is sometimes sent only to the second stage, F-2, the first stage receiving its water from the second stage recycle.

Three types of electrostatic desalters are currently used in the USSR. The oldest type, a vertical desalter with a vessel diameter of 3 meters and a 5-meter height, suffers from low throughput capacity and therefore has to be installed in units of 6-12 in parallel. To save on capital, the second type, a spherical desalter with a diameter of 10.5 meters, was used in installations built between 1955 and 1970. Its capacity approximates 300-500 cubic meters per hour, but its disadvantages are high production costs and difficulties because of its enormous size and inability to withstand high pressures. To solve these problems, a horizontal desalter has come into use in the USSR in recent years. Its diameters run from 3 to 3.4 meters and it has an internal capacity of 80-160 cubic meters. Because of its ability to withstand higher pressures and temperatures, the productivity of this unit is reported to be 2.6 times that of the spherical.

The performance of these desalters/dehydrators at refineries leaves much to be desired. By Soviet norms, the salt content of crude delivered for primary processing should not exceed 3-5 mg/liter. In the United States, a figure of 1 mg/liter is often achieved.

The reduction of salt is necessary to prevent corrosion and buildup of salts in the fuel oil fractions. As an example, the two-stage unit at the Ryazan refinery, which receives crude containing



Source: Reference 68.

Figure C-24

DIAGRAM OF ELECTROSTATIC DESALTER

1,750 mg/liter of salts, is able to desalt down to only 25 mg/liter. On the other hand, the Polotsk refinery, which receives oil from the Druzhba pipeline containing 40-50 mg/liter of salt, achieves desalting down to 5 mg/liter.[70] It has been estimated that if the average salt content in refined crude were to be lowered to 5 mg/liter, then the savings by 1975 would amount to nearly 150 million rubles per year.

Concomitant with the problems of desalting at the refineries is the problem of water use and water quality. The water usage may be approximately 10 percent of the crude treated. In view of the fact that almost 80 percent of all crude delivered to the refineries in the USSR is treated this way,[71] this amounts to a sizable water disposal and consumption problem. Until recently, apparently no efforts were made to treat wastes from refineries and not until 1968 were measures undertaken to require treating facilities to be installed to control these wastes.[72] By 1968, the amount of oil floating down the Volga River was large enough to cause the river in one instance to catch on fire.

It has also been found that installation of electrostatic desalters in the field requires fewer stages to achieve the same degree of desalting than would be required if the desalters were installed at the refineries. To optimize conditions for improved desalting and eliminate or reduce the problem of what to do with water wastes, an attempt has been made to combine all the crude preparation at the central bases in crude producing areas. These complexes might contain gas separators, water dehydrators and desalters, crude stabilizers, and gas processing and treating plants. An example of perhaps the most efficient complex of this type is the one located at the Mukhanovskoie field, near the city of Kuibyshev.[73] There, the central processing complex serves an area with a radius of approximately 80 km and receives crude oil and associated gas from approximately 29 oil fiels. The total quantity of oil processed there in 1971 approached 33 million tons (almost 10 percent of

total USSR production for that year), with approximately 1.3 billion cubic meters of associated gas. The use of associated gas was 88 percent, which is remarkable, considering that at least 30 percent of this gas was flared in 1970 in the USSR as a whole.[74] The crude coming from the farthest points in this system is degassed, the initial water is separated, and the crude is then pumped to the central processing station. There, it undergoes final water separation, desalting, and stabilization. The crude from fields closer than 10 miles, after initial degassing, is piped directly to the central processing station without undergoing any water separation in the field. The separated associated gas is processed at this central station for recovery of LPG. The separated water is pumped back into the producing formations for pressure maintenance or is disposed of in the nonproducing strata.

In view of the large amount of publicity and the formalization of plans to improve the quality of crude preparation and handling of water wastes in the 1971-1975 five-year plan, it is obvious that this problem is still plaguing the oil producers and refiners. Perhaps it is fortunate for the Soviet planners, having staked the growth of oil production in the next few years on the Western Siberia crudes, that the low level of mineralization of water in these crudes as well as the low content of asphaltenes and paraffins will make crude preparation a much simpler task than the preparation of some crudes in the Urals-Volga basin.

II PETROLEUM IN COMECON COUNTRIES OF EASTERN EUROPE

A. Overview of Oil and Gas Deposits in Eastern Europe

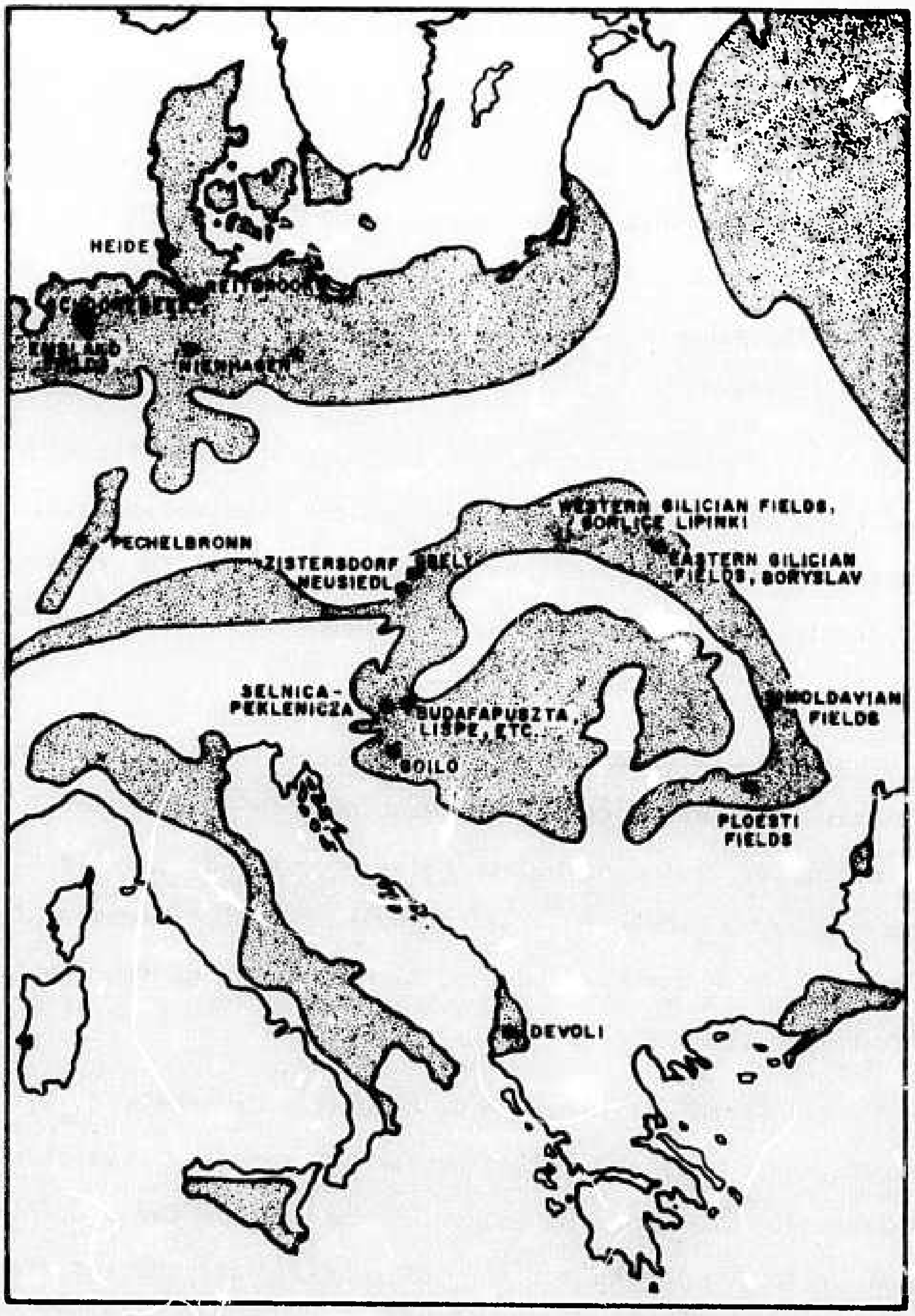
The locations of areas in Eastern Europe where conditions may be favorable for the occurrence of oil and gas are shown in Figure C-25. These areas are coincident with the locations of principal sedimentary basins, many of which are related to the mountain chains of the Alpine system.

The largest oil fields of Eastern Europe are located on the northern side of the Carpathian mountains. There are several great basins which contain a thick sequence of Tertiary sediments:

- The fields of western Czechoslovakia, extending into Austria on the west and Bavaria on the north.
- The belt of Polish oil fields, which continue eastward into part of the southwestern Ukraine. These fields lie along the northern slopes of the Carpathians in a strongly folded and faulted zone.
- The foothills of the eastern Carpathians of Romania.

Additional oil fields occur south and inside the Carpathian arc. These are generally shallow sedimentary basins deposited over older erosional surfaces. The principal oil fields are:

- The Plains of eastern Czechoslovakia and western Hungary (Pannonian Basin).
- The Transylvanian Basin of Romania, noted for its gas fields.
- The Great Plain of Hungary and northern Yugoslavia.



Source: Reference 75 .

Figure C-25

PROSPECTIVE OIL AREAS IN EASTERN EUROPE

The geological features of oil and gas deposits occurring in individual countries will be described separately in the sections that follow.

Table C-55 shows, in summary form, trends in estimated crude oil reserves of the Eastern European countries. By far the largest reserves are in the USSR, as noted previously. Equally interesting, however, is the growth in reserves over the last 30 years, resulting in more than a tenfold increase.

The next largest reserves are in Romania, 2.4 billion barrels, and these also show a substantial increase over time (especially in the last 3 years). Historically, estimates of Romanian oil reserves have varied considerably, and this doubtless introduces an added element of uncertainty into the analysis.

Hungary's oil reserves are next largest, about 1 billion barrels. This estimate is a twentyfold increase over 1969, and therefore needs to be carefully evaluated before being accepted as a valid expression of the country's recoverable oil deposits. Past estimates of Hungary's oil reserves have also varied over time, increasing the levels of uncertainty about their reliability.

The estimated oil reserves of Bulgaria, Czechoslovakia, German Democratic Republic, and Poland are small, totaling less than 100 million barrels. The reserves estimated for most of these countries have been at these low levels for several years. Only the reserves of Poland, which had been estimated at about 20 million barrels for some time, have seen a threefold increase in the last few years. These recent estimates remain to be thoroughly analyzed and verified through further analysis. In sections that follow, details of the geological characteristics pertinent to oil occurrence in the CMEA countries (other than the USSR) will be presented.

Table C-55

TRENDS IN ESTIMATED CRUDE OIL RESERVES
(Thousands of Barrels)

	1944	1949	1954	1960	1965	1969	1973*
USSR	5,735,000	4,275,000	9,000,000	28,000,000	29,250,000	40,000,000	75,000,000
Bulgaria	-	-	-	-	10,000	15,000	16,000
Czechoslovakia	1,200	2,000	25,000	12,000	10,000	12,000	12,000
German Democratic Republic	-	-	-	-	5,000	11,000	11,000
Hungary	75,000	40,000	55,000	200,000	125,000	50,000	1,000,000
Poland	30,000	20,000	20,000	25,000	25,000	20,000	60,000
Romania	392,000	350,000	400,000	1,000,000	950,000	750,000	2,382,000

Source: "Petroleum Facts and Figures" 1971 Edition. American Petroleum Institute.

* International Petroleum Encyclopedia, 1973.

1. Bulgaria

a. Resources

Commercial reserves of crude oil in Bulgaria are limited, with apparent recoverable reserves in 1973 being estimated at about 16 million barrels. Even the total amount of reserves is scattered among several small deposits, greatly complicating the prospective efficient use of the domestic oil reserves. It seems most unlikely that Bulgaria will be able to avoid reliance upon imports to meet most of its petroleum needs of the future.

b. Production, Refining, and Trade*

To satisfy the demands for energy in the future, Bulgaria is faced with the prospects of increasing reliance on imports for its fuel supplies. Part of this energy demand will be met by construction of nuclear power plants, but most of it will be met by imports of crude oil, oil products, and natural gas. Bulgarians have estimated that to meet their planned economic growth, they would have to import 74 to 75 percent of all energy consumed in the country by 1980. This is probably a low estimate if one considers that nuclear power features very strongly in Bulgarian calculations. In 1970 approximately 60 percent of all internal energy demands were met by imports.

Bulgaria relies heavily on imports of both crude and oil products for its internal demands, with most of these products supplied by the USSR. The structure of oil and refined products production and trade can be seen in Table C-56. While the USSR supplies most of the

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* Unless otherwise indicated, most information was obtained from Russian sources or various statistical annuals published by Eastern European countries. These references are listed at the end of this report.

Table C-56

OIL AND REFINED PRODUCTS PRODUCTION AND TRADE IN BULGARIA
(Thousand Metric Tons)

	1960	1965	1970	1971	1975	1980
Crude Oil						
Crude oil production	200	229	334	305	300*	300*
Imports	12	2,200	5,696	7,547	11,700-12,700	17,700-19,700
Exports	72	4	108	-	-	-
Net internal supply	140	2,425	5,922	7,852	12,000-13,000†	18,000-20,000†
Refined Product						
Total refined product‡	153	2,272	5,965	7,220§		
Imports	961	1,439	2,876	2,550		
Exports	1	89	154	72		
Apparent internal consumption	1,084	3,652	8,687	9,698		

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* SRI estimates.

† Soviet estimates from Voprosy Ekonomiki, No. 12, 1971, p. 50.

‡ There is an unresolved statistical difference between crude supply and refined product output for 1960 and 1970. The refined product output was obtained by summing all reported production of individual products for that year.

§ SRI estimate, based on 92 percent product yield.

oil and oil products, there has been a significant increase of imports from Africa and the Middle East. According to Soviet prognosticators, the probability of larger imports from countries outside the COMECON bloc is very real. The bulk of oil imports in the near future will still be supplied by the USSR. The sources of Bulgarian crude imports can be seen in Table C-57. The imports of oil products, although they have been growing in the last 10 or so years, are now leveling off and will probably not grow significantly as internal refining capacity is built up.

Bulgaria has three major refineries at this time, with a fourth one in the planning stage. These are at Pleven, Ruse (across from Romania on the Danube river), and Burgas, the biggest refinery, located on the Black Sea coast. The total refining capacity was estimated to be 6 million metric tons (120,000 barrels per day) in 1970 and is expected to grow to about 14 million tons per year by 1975 with a major expansion at Burgas and some additional capacity at the Pleven refinery. (See Table C-58.) A new refinery is being planned, and if that one is commissioned on time, the refining capacity should grow to about 18 million metric tons per year by 1980. This capacity should satisfy the oil products demand, as envisioned by the Bulgarians.

The production of refined products up until 1960, based mainly on domestic crude, leaned heavily on mid distillates and residuals. However, as new capacity and imported crudes began to feature strongly in Bulgarian refining, the product slate changed and by 1970 reflected a structure similar to that of the USSR (Table C-59). This is not surprising in view of the fact that Bulgarian refining depends heavily on Soviet technology. Of course the growth in motor fuel demands contributed greatly to the necessity of changing the production pattern. The refinery product slate and refinery capacity estimates for Bulgaria are shown in Table C-59.

Table C-57

CRUDE OIL IMPORTS OF BULGARIA
(Thousand Metric Tons)

	1965		1970		1975	
From COMECON	tons	percent	tons	percent	tons	percent
USSR	2,146		4,766		11,400*	
Subtotal	2,146	98	4,766	84	11,400*	90-97
From others						
Algeria			200			
Egypt			300			
Iran			250			
Syria			180			
Subtotal	54	2	930	16	300-1,300	3-10
Total	2,200	100	5,696	100	11,700-12,700	100

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* Soviet estimate from Ekonomika promyshlenosti, No. 6, 1971.

Table C-58

ESTIMATED REFINING CAPACITY IN BULGARIA
(Million Metric Tons)

Year	Million Tons
1960	0.15
1965	2.5
1970	6.0
1971	8.0
1975*	14.0
1980*	18.0

* Bulgarian plan.

Table C-59

REFINERY PRODUCT SLATE IN BULGARIA
(Percent of Total)

Product	1960	1965	1970
Gasoline	Negl.	16.3%	19.3%
Kerosene	Negl.	3.3	2.1
Diesel fuel	22.9%	27.5	29.0
Lubricating oil	15.7	2.1	0.9
Residual fuel oil	42.5	48.3	46.6
Others	18.9	2.5	2.1
Total	100.0%	100.0%	100.0%

Bulgarian oil product exports are insignificant and will not be important in plans for future growth in refining capacity. The refining facilities will be added for meeting internal needs only. The one important change that may take place leading to further altering of refining practice will be caused by the demands of the growing petrochemical industry for feedstocks. The petrochemical industry in Bulgaria is going to rely on naphtha for its fuels. The production and disposition of individual oil products in Bulgaria is shown in Table C-60.

c. <u>Oil Transport</u>

Figure C-26 is a map of fuel transport in Bulgaria.* Numbers given below after cities refer to the numbers in the figure.

Bulgaria has exploited two small oil fields--first, those of Tyulenovo (19), from which crude is piped through a 20 kilometer pipeline to Kavarna (20) and then carried by ocean tanker to the refineries at Burgas (5); and second, the oil fields near Pleven (21), which are connected by pipelines of 22 cm diameter to refineries in the city of Pleven. Bulgaria's total production of crude in these two oil fields in 1970 was a modest 397,000 tons.

Bulgaria relies heavily on Soviet and Romanian oil, and in 1970 Bulgaria imported 5.7 million tons of crude and 1.3 million tons of oil products from the USSR and about 1 million tons of oil products from Romania. The Soviet oil was transported by ocean tanker to Burgas, where the crude was refined in local refineries, and the Romanian oil

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* This map is also used in other volumes of this report, since it shows oil pipelines, gas pipelines, rail lines, and water routes. In the following pages, discussions of oil transport will use the fuel transport maps.

Table C-60

SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS IN BULGARIA
(Thousand Tons)

	1960	1965	1970	1971
Gasoline				
Production	-	371	1,153	n.a.
Imports	335	157	267	116
Exports	-	8	29	26
Apparent consumption	335	520	1,391	
Kerosene				
Production	-	74	126	n.a.
Imports	20	11	8	n.a.
Exports	-	-	-	n.a.
Apparent consumption	20	85	134	n.a.
Diesel fuel				
Production	35	625	1,732	n.a.
Imports	406	334	512	412
Exports	-	29	81	7
Apparent consumption	441	930	2,163	
Lubricating oil				
Production	24	47	53	n.a.
Imports	39	54	87	46
Exports	-	10	3	4
Apparent consumption	63	91	137	
Residual fuel oil				
Production	65	1,097	2,777	3,721
Imports	116	819	1,768	1,666
Exports	1	41	41	8
Apparent consumption	180	1,875	4,504	5,379
Other products*				
Production	29	58	124	n.a.
Imports	45	94	234	n.a.
Exports	-	1	-	n.a.
Apparent consumption	45	151	359	n.a.
Total products*				
Production	153	2,372	5,965	7,220†
Imports	961	1,469	2,876	2,550
Exports	1	89	154	72
Apparent consumption	1,113	3,652	8,687	9,698

n.a. - not available.

* Includes asphalts, wax, coke, etc., but excludes LPG.

† SRI estimate, based on 92 percent product yield.

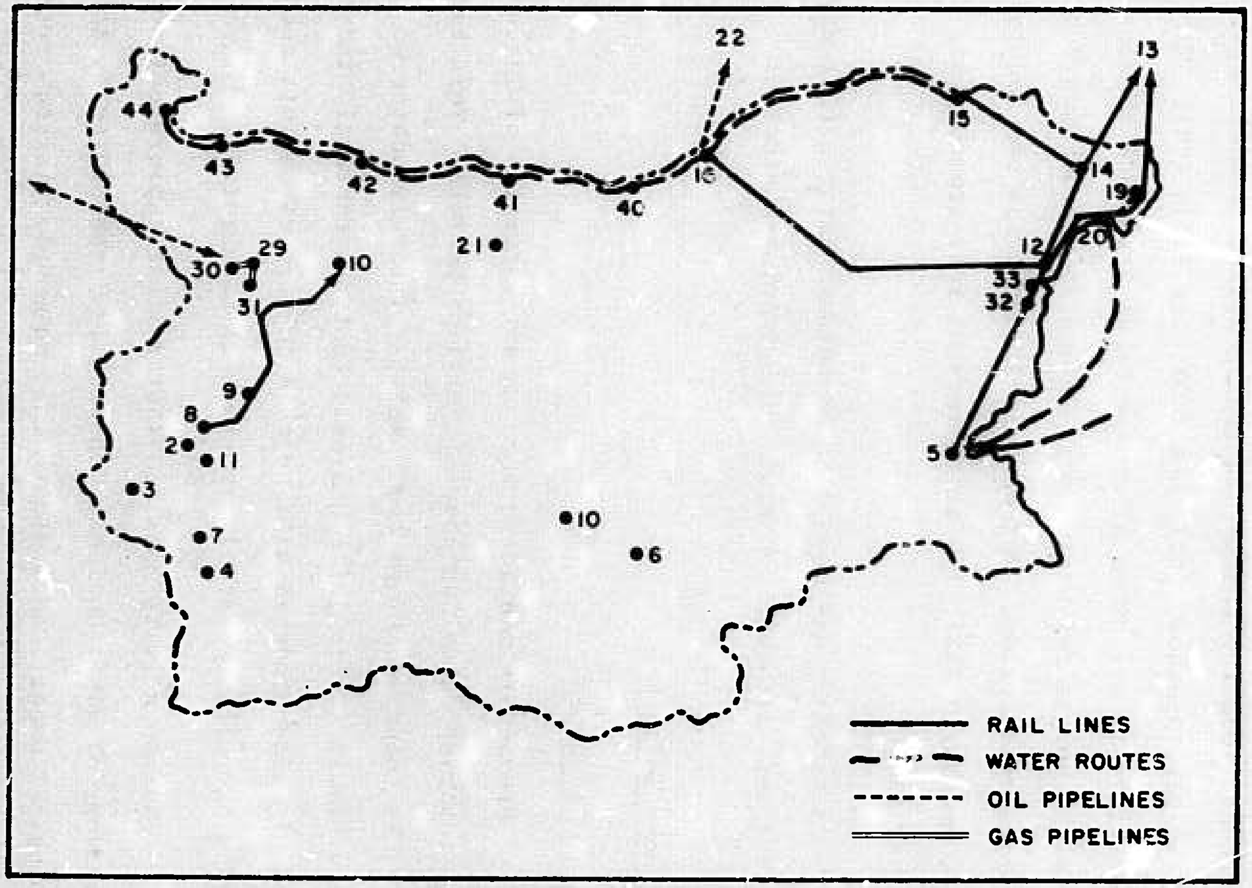

Figure C-26

FUEL TRANSPORT IN BULGARIA

was piped through a product pipeline from Ploesti (22) to Ruse (17)-- a distance of 140 kilometers.

Oil products are shipped by river tanker from Ruse to residential towns along the Danube, including Silistria (16), Svishtov (40), Samoviet (41), Orekhovo (42), Lom (43), and Vidin (44). The total distance from Vidin to Silistrea along the Danube is 400 kilometers. Products from the Burgas refineries are transported throughout Bulgaria by the Bulgarian rail system. Petrochemical industries are located at Ruse, Burgas, and Varna (13), 110 kilometers by rail from Burgas, and in the vicinity of Pleven.

A pipeline has been planned between Kavarna (20) and Pleven's refineries, although construction has not yet started.

2. Czechoslovakia

a. Resources

Previously mentioned were recent estimates of Czechoslovakia oil reserves, totaling about 12 million barrels. This rather small reserve is comprised of several small, relatively scattered deposits. As a result, it is quite unlikely that the currently indicated oil reserves of Czechoslovakia will be able to support her oil needs, and an increasing reliance on oil imports will be required.

Although it is possible that further exploratory work may lead to discovery of additional oil deposits in Czechoslovakia, the general geological conditions indicate that no substantial new reserves will be encountered. It is more likely, instead, that Czechoslovakia will continue to be an oil-poor country that will have to rely on her trading partners to achieve necessary supplies of liquid (and gaseous) hydrocarbon fuels.

The trends in the fuel balance of Czechoslovakia are shown below (in percent).

	1960	1965	1970	1975	1980
Solid fuels	90.7%	85.7	75.2	66.5	57.1%
Liquid fuels	1.7	5.5	17.7	25.0	28.0
Natural gas	0.4	2.6	3.2	4.4	7.9
Other	7.2	6.2	3.9	4.1	7.0

The forecast increase in liquid fuels is projected in anticipation that the coal reserves of Czechoslovakia will be insufficient to support any further increase in production after 1980. Since Czechoslovakia's oil reserves are small, it seems inescapable that imports of liquid fuels will be required. It was noted recently in this regard that "From the point of view of transportation expenditures and from the point of view of prices, the import of crude oil from the USSR is the most advantageous for the USSR."[76]

b. Refining

Czechoslovakia, like most of the Eastern European Soviet satellites, is faced with an increasing energy crunch and will depend more heavily on imports to make up the energy deficits. It is estimated by the Czechs that in order to keep a reasonable economic growth rate, as much as 40 percent of its total energy needs will have to come from abroad. The share of imported energy accounts for approximately 20 percent of the total annual demand at present.

Oil is going to have the lions' share of this growth in energy demand, with most of it coming from the USSR via the Druzhba pipeline. The Czechs estimate that oil should account for approximately 26 percent of total energy demand by 1980. Indigenous oil production is insignificant and is not likely to feature importantly in the future. Although the USSR will remain the chief supplier of oil to the Czechs,

a growing proportion of their imports may be coming from Africa and the Middle East in the near future. Czechoslovakia had concluded a cash and barter agreement with Iran in 1969 for deliveries of crude from that country. This agreement carries a monetary tag which is about half that on a similar barter agreement made with Russia for the period 1971 to 1975, indicating fairly substantial oil imports from Iran.

As in other Eastern European countries, oil product imports do not share a significant proportion of the internal oil product consumption, with future plans calling for expansion of refining capacity to keep pace with the rising demands for refined products. Crude oil and refined products trade and production, for a few selected years, are shown in Table C-61.

Czechoslovakia had an estimated refining capacity of 12 million metric tons per year (240,000 barrels per day) in 1971, with the major share of it concentrated at the refinery near Bratislava. The planned expansion of this refinery and the one at Kralupy, and the building of a planned new one in Moravia, should double the present refining capacity to approximately 450,000 to 500,000 barrels per day by 1980.

Czechoslovakia has the industrial capability of supplying its own equipment for refineries. Although the refineries are designed on Soviet models, the basic equipment is manufactured locally. In fact, the USSR has been receiving Czech refining equipment for some years, and this trade is likely to grow in the future in view of the barter agreements reached between Czechoslovakia and the USSR. The Czechs agreed to supply refining equipment, pipe, and other equipment for promised deliveries of crude.

The refinery product slate for a few selected years is shown in Table C-62.

Table C-61

OIL AND REFINED PRODUCTS PRODUCTION AND TRADE IN CZECHOSLOVAKIA
(Thousand Metric Tons)

	1960	1965	1970	1971
Crude Oil				
Crude oil production	137	192	203	194
Imports	2,255	6,096	9,798	11,505
Exports	-	137	47	63
Net internal supply	2,292	6,151	9,954	11,636
Refined Product				
Total refined product	2,022	5,060	7,808	9,309*
Imports	460	774	1,087	995
Exports	213	977	761	878
Apparent internal consumption	2,269	4,857	8,134	9,426

* Assuming 80 percent yield on net apparent crude supply.

Table C-62

REFINERY PRODUCT SLATE IN CZECHOSLOVAKIA
(Percent of Total)

Product	1960	1965	1970
Gasoline	21.2%	11.4%	11.5%
Kerosene	4.1	2.7	3.1
Diesel fuel	19.3	25.3	21.4
Lube oils	3.9	2.3	1.7
Residual fuel oil	38.6	50.1	51.4
Others	12.9	8.2	10.9
Total	100.0	100.0	100.0

The changes in the refining product slate that took place in the mid-sixties reflected the growing consumption of diesel fuel and residual fuel oil. By 1970 product structure had reached a fairly good balance between production and consumption and is likely to remain nearly the same in the future--stress production of diesel fuels and residual fuel oils. The share of gasoline may creep up a little at the expense of the residual fuel oils. The expansion of the petrochemical industry will rely heavily on normal gas, supplied by USSR. The supply and disposition of petroleum products in Czechoslovakia are shown in Table C-63.

c. Oil Transport

Figure C-27 shows fuel transport in Czechoslovakia. Numbers given below after cities refer to numbers in the figure.

Czechoslovakia produced 203,000 tons of crude oil in 1970 in the lower Morava valley near Breclav (13). This oil is piped over a 100 kilometer line to refineries in Bratislava (14), a large industrial

Table C-63

SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS IN CZECHOSLOVAKIA
(Thousand Tons)

	1960	1965	1970	1971
Gasoline				
Production	428	576	898	1,174
Imports	10	114	402	341
Exports	57	141	188	74
Apparent consumption	381	549	1,112	1,441
Kerosene				
Production	83	137	239	276
Imports	210	243	400	n.a.
Exports	-	-	-	n.a.
Apparent consumption	293	380	639	n.a.
Diesel fuel				
Production	390*	1,279	1,668	n.a.
Imports	-	77	11	6
Exports	-	351	277	277
Apparent consumption	35	1,005	1,402	364
Lubricating oil				
Production	79	115	134	n.a.
Imports	2	38	55	10
Exports	40	11	70	9
Apparent consumption	41	142	119	n.a.
Residual fuel oil				
Production	780*	2,536	4,011	4,784
Imports	2	60	143	161
Exports	106	437	175	291
Apparent consumption	380	2,159	3,979	4,654
Other products†				
Production	262	417	858	n.a.
Imports	236	242	76	n.a.
Exports	10	37	51	n.a.
Apparent consumption	488	622	883	n.a.
Total products*				
Production	2,022	5,060	7,808	9,309‡
Imports	460	774	1,087	995
Exports	213	977	761	878
Apparent consumption	2,022	4,857	8,134	10,426

n.a. - not available.

* Diesel fuel and residual fuel oil reported as an aggregate for 1960. The ratio of diesel fuel to residual was assembled the same as in 1965.

† Includes asphalt and coke but excludes LPG.

‡ Assuming 80 percent yield on net apparent crude supply.

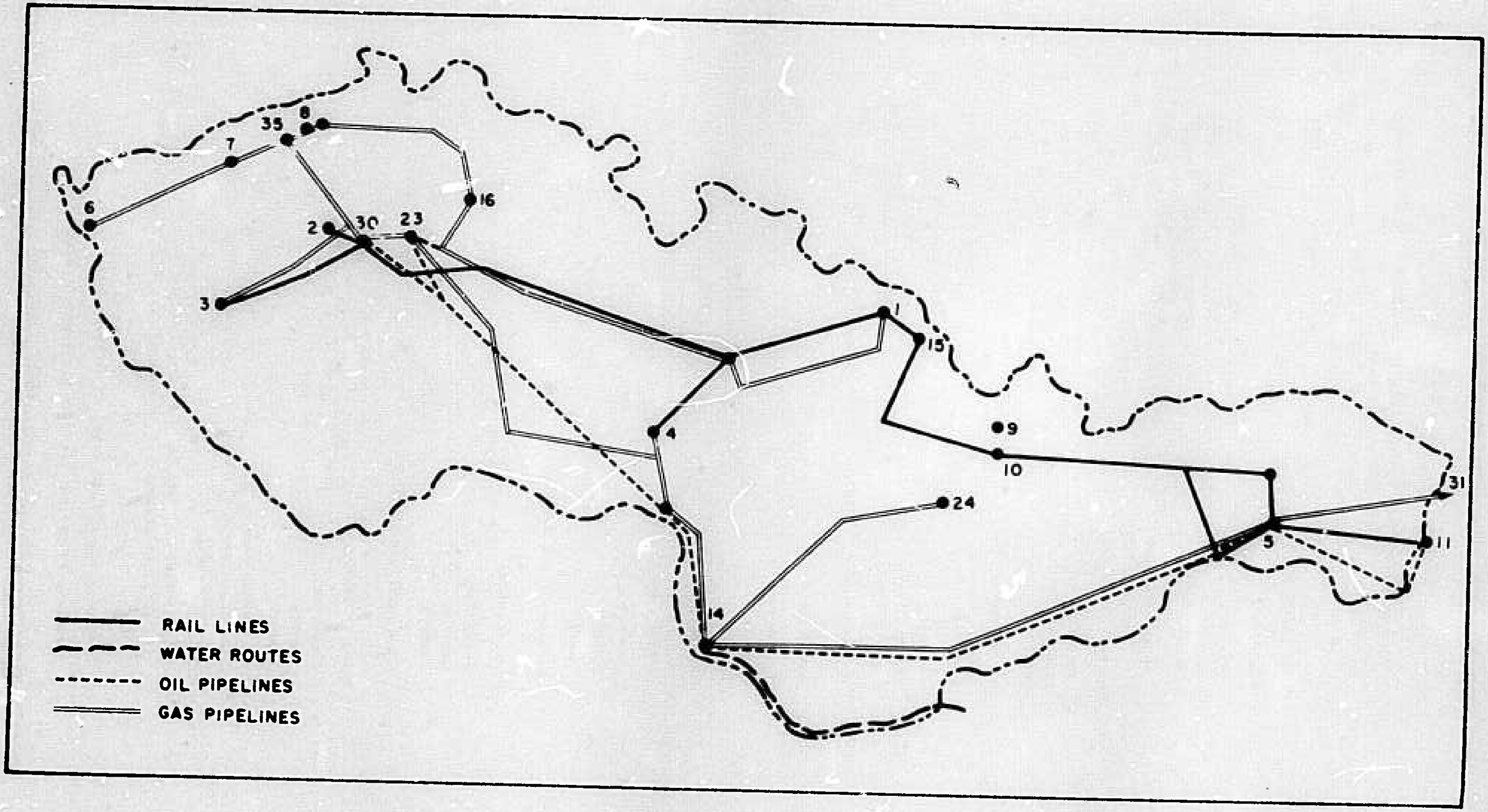

Figure C-27

FUEL TRANSPORT IN CZECHOSLOVAKIA

town with steel and chemical plants, which also received 9.8 million tons of crude from the Druzhba pipeline. This pipeline on the Ukrainian-Czech border to Bratislava stretches over 430 kilometers of Czech territory from Uzhgorod (11) in the USSR. In addition to crude oil from the lower Morava valley and the USSR, Czechoslovakia also imported 1.1 million tons of oil products in 1970, of which 400,000 tons were transported by river tanker from Romania up the Danube to Bratislava, and 700,000 tons were transported from Uzhgorod by rail to the metallurgical, coal-mining, and thermal electric power producing center of Trinec (15), 380 kilometers from Uzhgorod by rail, and Ostrava (1), 490 kilometers.

There are also small refineries at Kolin (23) and Pardubice (16), which are both steel-making and chemical-producing cities. A pipeline 51 cubic meters in diameter stretches from the oil fields of Lower Morava (13) 200 kilometers to Kolin and 50 kilometers from Kolin to Pardubice.

3. German Democratic Republic

a. Resources

Traces of oil have been found in the southern part of the German Democratic Republic (East Germany), although these surface shows are quite rare. The overall thickness of sediments is estimated to be 4,000 to 5,000 meters, and it is possible for oil deposits to have been formed in these conditions. However, no commercial oil and gas deposits have yet been discovered, and East Germany must rely on imports for these supplies.

b. Refining

Until the sixties, the GDR depended heavily on synthetic liquid fuels, based on semicoking and coking operations performed

primarily on low grade brown coals, for its motor fuels and chemical feedstocks. The growing demands on energy in all sectors of the economy made it difficult to expand the production of brown coal, on both technical and economic grounds, and forced the East Germans to look for foreign supplies of crude. The indigenous production of crude is insignificant in spite of heavy exploration efforts made in recent years with Soviet help. Almost all of the imported oil comes from the USSR, with future supplies likely to be supplied primarily by the same source.

Table C-64 below shows the production and trade in oil and liquid refined products for a few selected years. The refined product total exceeds the internal net crude oil supply by a substantial quantity. This is due to still large production of liquid fuels, including motor gasoline, from liquid and tar byproducts of coal processing. Whereas until the early sixties motor fuel supplies depended heavily on this source, crude oil now supplies the major share of gasoline while the chemical industry still depends heavily on synthetic liquid coal byproducts for its feedstocks. Very little information is available on East German use of synthetic liquid stocks for the chemical industry; however, from various statements on production goals in East German literature, from Soviet statements about oil product demand in East Germany in connection with their crude trade, and from the increased production of coal derived liquid products, one can assume that coal byproducts are still an important base for their chemical industry. It has been stated by the Soviets[77] that in 1965, all of the synthetic organic industry in East Germany was based on brown coal and carbide technology. By 1970 the share of oil in this industry had grown to 25 percent, and by 1975 it is expected to be 50 percent. The expansion of the generating capacity of thermal electric stations is going to depend primarily on brown coal and thus divert the limited supplies of brown coal that might otherwise have gone to the chemical industry.

Table C-64

OIL AND REFINED PRODUCTS* PRODUCTION AND TRADE IN EAST GERMANY
(Thousand Metric Tons)

	1960	1965	1970	1971
Crude Oil				
Crude oil production	-	80	300	
Imports	1,941	5,132	10,334	10,919
Exports	-	-	-	-
Net internal supply	1,941	5,212	10,634	
Refined Product				
Total refined product	2,216	5,557	11,377	12,108
Imports	658	561	109	182
Exports	1,019	1,680	1,312	990
Apparent internal consumption	1,855	4,438	10,174	11,300

* Including synthetic liquid fuels from coal processing.

The total oil refining capacity of East Germany was estimated to be 11 million metric tons (220,000 barrels per day) in 1970 and is expected to grow to about 18 million tons by 1975, according to the East German current five-year plan. An additional refining capacity, based on brown coal synthetic liquids, of about 1.5 million tons was available at the old synthetic oil refineries at Böhlen and Zeitz. The main oil refining capacity is concentrated at the Schwedt refinery on the Oder River, with crude supplied by a 20-inch pipeline from the USSR. This refinery was estimated to have 150,000 barrels per day in late 1970 and is expected to grow significantly by 1975 to perhaps 250,000 barrels per day. Three other refineries near Leipzig--at Lenna, Lützkend, and Böhlen--account for most of the remaining crude oil refining capacity. These last are also linked by pipeline to the COMECON crude line at Schwedt. Another 24-inch parallel line is being completed to Schwedt, with an ultimate capacity of approximately 20 million tons per year for both strings. This should certainly be sufficient to supply all of the crude demands in East Germany by 1975.

The new refinery at Schwedt was built on Soviet design but with equipment of mostly East German manufacture. The oil product slate is estimated to be as shown in Table C-65, stressing residual fuel oils. It is expected to shift a little to increase the supplies of diesel fuel.

Table C-65

REFINERY PRODUCT SLATE IN EAST GERMANY
(Percent of Total)

Product	1960	1965	1970
Gasoline	33.2%	27.4%	21.5%
Distillate fuels*	21.0	26.9	22.6
Lube oils	12.1	5.8	3.5
Residual fuel oils	26.3	35.6	46.7
Other	7.4	4.3	5.7
Total	100.0	100.0	100.0

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* Including diesel fuel and kerosenes.

Table C-66 shows the production and disposition of refined products, including coal-based fuels, in East Germany.

c. Oil Transport

Figure C-27 shows fuel transport in the GDR.

In 1970, the GDR imported 9.3 million tons of crude oil through the 48-inch Druzhba pipeline, which terminates at Schwedt (24). Some of the oil was used in refineries at Schwedt, but most of it was transported by rail from Schwedt along the 270 kilometer Schwedt-Berlin (9)-Leipzig (3)-Halle (10) rail line to refineries and chemical plants in the Halle-Leipzig province, the largest chemical-production center in the GDR.

Oil products are dispatched from Schwedt and the Halle-Leipzig region to virtually every city in the country by rail.

Table C-66

SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS* IN EAST GERMANY
(Thousand Tons)

	1960	1965	1970	1971
Gasoline				
Production	1,080	1,604	2,236	2,359
Imports	230	130	0	n.a.
Exports	380	597	464	444
Apparent consumption	930	1,137	1,772	1,915
Kerosene				
Production				
Imports		-	-	n.a.
Exports		-	-	n.a.
Apparent consumption				
Diesel fuel†				
Production	393	1,723	3,619	3,619
Imports	242	303	0	n.a.
Exports	375	675	504	243
Apparent consumption	260	1,351	3,115	3,862
Lubricating oil				
Production	218	286	352	346
Imports	35	54	28	36
Exports	97	0	7	9
Apparent consumption	156	340	373	373
Residual fuel oil				
Production	393	1,723	4,604	5,096
Imports	8	27	13	54
Exports	98	269	205	110
Apparent consumption	303	1,481	4,412	5,040
Other products				
Production	132	221	566	688
Imports	143	47	68	n.a.
Exports	69	139	132	n.a.
Apparent consumption	206	129	502	688
Total products				
Production	2,216	5,557	11,377	12,108
Imports	658	561	109	182
Exports	1,019	1,680	1,312	990
Apparent consumption	1,855	4,438	10,174	11,300

n.a. - not available.

* Excluding LPG but including products from coal tar refining.

† Including kerosene and jet fuel.

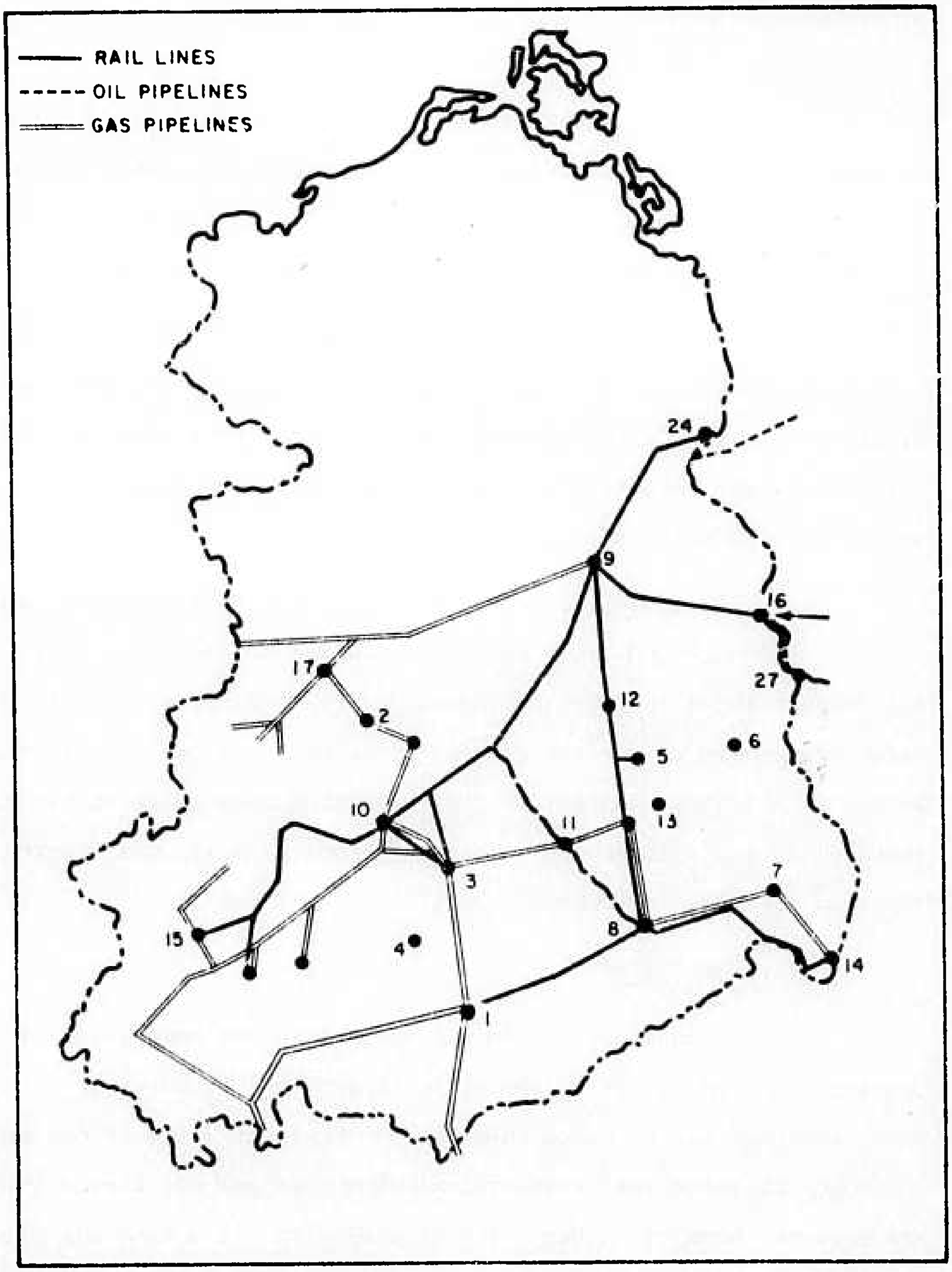

Figure C-28
FUEL TRANSPORT IN THE GERMAN DEMOCRATIC REPUBLIC

4. Hungary

a. Resources

As previously noted, Hungary is in a deep structural basin largely filled with sedimentary rocks representing a range in age from Paleozoic to Tertiary. Numerous surface shows of oil are present, and traces of methane have been reported in waters of many artesian wells.

More than 60 economic oil and gas accumulations are known. Extensive geophysical exploration was conducted to guide exploratory drilling. In recent years, a program of extensive exploratory drilling was undertaken. Apparently this program led to the increase in oil reserves noted previously.

Oil and gas deposits of Hungary occur mainly in sandstone strata. Although most occurrences are in folded domes and anticlines, oil is also found in fault-block-bounded reservoirs, especially in limestone reservoirs of certain areas. Lithologic control of oil occurrences is expressed in most of the reservoirs in clastic rocks; these commonly have a comparatively large gas cap, with the oil occurring above an active water body.

b. Refining

Commercial crude oil production has been going on in Hungary since 1937. It is the third largest oil producer in the COMECON bloc, trailing the USSR and Romania. However, in spite of constant minor growth since the accidental discovery of new oil fields in the mid-sixties, production has not kept pace with oil demand and Hungary has had to rely on ever increasing imports of crude, mainly from the USSR. The Hungarians estimate that by 1980 approximately 50 percent of their primary energy needs will be met by imports, with oil and gas making up most of these imports. The structure of oil and refined

products production and trade for a few selected years can be seen in Table C-67. Hungary plans to increase its imports of oil from the USSR to 6.5 million tons per year by 1975 through construction of a pipeline running from the COMECON Druzhba pipeline at Suhy in Czechoslovakia to the Szazhalombatta refinery near Budapest.

The major share of the total refining capacity in Hungary which was estimated to be 6.5 million metric tons per year (130,000 barrels per day) in 1970, falls on the Szony and the Szazhalombatta refineries. The first has an estimated primary distillation capacity of about 40,000 barrels per day, and the second, 60,000 barrels per day. The remaining 30,000 barrels per day are divided evenly between Nyirbogdany, Pét, and the Zalaegerszeg refineries.

Current plans call for the expansion of the Szazhalombatta refinery to a total capacity of 120,000 barrels per day by 1975. This should bring the aggregate refining capacity in Hungary to about 9 million tons per year, as indicated in the Hungarian 1971-1975 five year plan. Future plans call for construction of new refineries at Teninvaros and Tiszapolgar to provide an additional capacity of 160,000 barrels per day, thus doubling their present crude processing capability by 1980.

Most of the equipment that is being installed is of Soviet origin and reflects, in its design and processing, the current Soviet practice of comparatively little secondary processing, stressing the production of straight run distillates and residual fuel oils. The product slate of Hungarian refineries is shown in Table C-68. Although it includes production of distillates from coal processing, their quantities are of such minor importance that they do not affect the final breakdown to any great extent.

Table C-67

OIL AND REFINED PRODUCTS PRODUCTION AND TRADE IN HUNGARY
(Thousand Metric Tons)

	1960	1965	1970	1971	1975
Crude Oil					
Crude oil production	1,217	1,803	1,937	1,955	
Imports	1,456	2,251	4,349	4,892	6,500*
Exports	34	121	292	188	
Net internal supply	2,639	3,933	5,994	6,659	9,000†
Refined Product					
Total refined product	2,533	3,854	5,915	6,354	8,500‡
Imports	116	516	974	809	
Exports	676	692	921	501	
Apparent internal consumption	1,973	3,678	5,968	6,662	8,500§

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* Planned imports from USSR.

† Estimate based on planned refining capacity in 1975.

‡ Estimated assuming 94 percent yield on refining charge.

§ Assuming balance between imports and exports of refined products.

Table C-68

REFINERY PRODUCT SLATE IN HUNGARY
(Percent of Total)

Product	1960	1965	1970	1971
Gasoline	12.9%	11.6	17.7	17.1%
Kerosene	2.0	0.5	negl.	negl.
Diesel fuel	28.9	27.1	32.9	34.5
Lube oils	4.7	3.2	2.8	2.8
Residual fuel oil	39.0	44.8	38.5	36.9
Other	12.5	12.8	8.1	8.7
Total	100.0	100.0	100.0	100.0

The supply and disposition of their individual products are given in Table C-69.

It is unlikely that this product slate will change in the near future. The demand for gasoline is not expected to grow appreciably, while the expansion of petrochemicals production is slated to depend mainly on ethylene and propylene produced from LPG in a natural gas plant to be built by the Soviets in Hungary. The residual fuel oil yield should remain about the same, with the rising demand for this product in the electric power industry. It is planned that most of the new thermal electric power plants in Hungary are to use fuel oil. In view of this, no major programs are likely to be undertaken by the Hungarians in the near future to upgrade the secondary processing capability.

c. Oil Transport

Figure C-29 shows fuel transport in Hungary.

Table C-69

SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS IN HUNGARY
(Thousand Tons)

	1960	1965	1970	1971
Gasoline				
Production	326	448	1,045	1,089
Imports	11	108	105	149
Exports	101	150	323	231
Apparent consumption	236	406	827	1,007
Kerosene				
Production	50	21	1	4
Imports	-	62	136	121
Exports	-	-	-	n.a.
Apparent consumption	50	83	137	
Diesel fuel				
Production	731	1,045	1,948	2,190
Imports	20	160	298	246
Exports	162	164	186	75
Apparent consumption	589	1,041	2,060	2,361
Lubricating oil				
Production	119	123	167	181
Imports	8	42	15	16
Exports	39	8	27	34
Apparent consumption	88	157	155	163
Residual fuel oil				
Production	988	1,725	2,276	2,344
Imports	70	102	388	223
Exports	223	178	302	99
Apparent consumption	835	1,649	2,362	2,468
Other products*				
Production	319	492	478	546
Imports	7	42	32	54†
Exports	151	192	136	62†
Apparent consumption	175	342	374	538
Total products				
Production	2,533	3,854	5,915	6,354
Imports	116	516	974	809
Exports	676	692	921	501
Apparent consumption	1,973	3,678	5,968	6,662

n.a. - not available.

* Including paraffin wax and bitumen but excluding LPG.

† Assuming no kerosene exports.

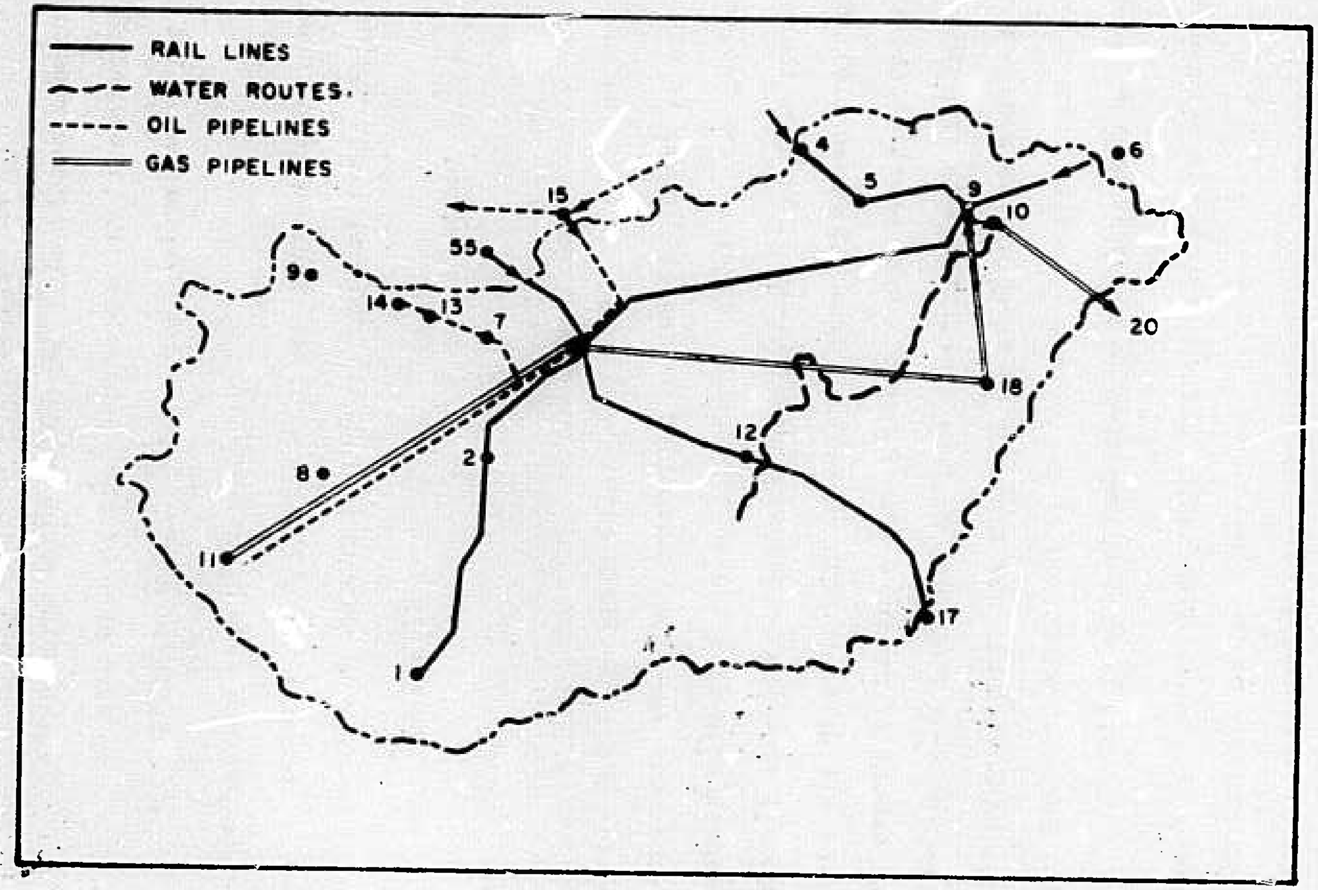

Figure C-29

FUEL TRANSPORT IN HUNGARY

Most of the 1.9 million tons of crude oil produced in Hungary in 1970 was from the Zala oil fields near Ujudvar (11), although a small amount was produced in fields near Szolnok (12) in the Tisza river valley. Oil from Ujudvar is piped 225 kilometers to Budapest (3) and 385 kilometers to the aluminum-smelting town of Almasfuzito (13) and Szony (14). All three destination points contain oil refineries.

Oil is also transported to Budapest by the 100 kilometer Sahy (15)-Budapest extension of the Druzhba pipeline. In 1970 4.3 million tons of Soviet oil was transported through this pipeline to Budapest. In the same year 500,000 tons of oil products from the USSR, and an equal amount of products from Romania, were imported into Hungary. The Soviet oil products entered by rail from Mukachevo (16) and the Romanian oil from the border station of Gyula (17); from these points, oil products were distributed throughout Hungary. From the refineries at Szolnok, oil was also transported by rail and river to other points, principally along the Tisza river.

5. Poland

a. Resources

Three regions of Poland, covering about 250,000 square kilometers, contain oil and gas deposits. These will be separately described below (see also Figure C-25).

- Carpathian Region. The folded sediments of the southwestern part of the country are the principal oil- and gas-bearing areas of Poland. The hydrocarbons occur mainly in clastic sediments of Tertiary age.
- Carpathian Foredeep. This region occurs directly north of the Carpathian fold region. Here, Mesozoic sediments were

deposited in basins, and were disturbed by the Alpine mountain formation during which favorable structures were produced for bitumen accumulation. Oil and gas occurs both in clastic sediments and in limestones in this area.

- Platform Region. The central part of Poland is a broad lowland in which Paleozoic and Mesozoic formations appear to have structures favorable for oil and gas accumulation. However, few deposits have been found, mainly in the West-Central part of the country.

Poland's encouraging structural and stratigraphic conditions have led to efforts for extensive exploration, and recently new sizable deposits of oil and gas have apparently been discovered. This has been the result of a continued effort of geophysical exploration, followed by exploratory and developmental drilling. The exploration has been carried progressively to greater depths:

	1961	1965	1969
Average depth of exploratory drilling	1,220 meters	1,443	1,745

Much of this exploration activity has been carried out in the Carpathian foothills and in the margins of the Sudeten region, where most of the recent successes have been achieved.

b. Refining

Production of crude oil in Poland accounts for less than 5 percent of total internal oil demand and is unlikely to grow sufficiently in the future to satisfy the growing demand for refined products. The projected demand for hydrocarbons, even with the recently expanded production of natural gas, will require substantial imports of both oil and gas in the future. All of the oil shipments to Poland arrive by

way of the Druzhba pipeline from the USSR. The oil and refined products trade and production are shown in Table C-70.

The biggest refinery in Poland is the Plock refinery near Warsaw. It accounted for approximately 4 million metric tons per year (80,000 barrels per day) of the total estimated refining capacity of 7.5 million tons in 1970. The other five refineries, Czechowice, Trzerbina, Mariampolski, Jaslo, and Jedlicze shared the remaining 3.5 million tons. A new refinery of approximately 3 million metric capacity (64,000 barrels per day) is scheduled for completion at Danzig (Gdansk) by 1975, to be expanded to 6 million tons by 1978, and the Plock refinery is to be expanded to approximately 10 million tons by 1975, thus bringing the refining capacity to approximately 17 million tons per year by the end of 1975. Another new refinery is being planned for construction at Blachowina, with a 6 million ton capacity (120,000 barrels per day) for completion by 1980.

The expansion of the petrochemical industry and demands for motor fuel will determine the future product slate of Polish refineries. Expansion of the thermal power plants' generating capacity is planned to be fueled mainly by lignite and brown coals. The present product slate is shown in Table C-71. It shows a rather high proportion of motor fuels in relation to residual fuel oils.

The expansion of high quality motor fuels production and provision of suitable feedstocks for the petrochemical industry requires a fairly sophisticated secondary refining capability. It is perhaps significant that the Poles have turned to the West (UOP) for catalytic cracking design for their expansion at Plock, as well as to Foster Wheeler and Snam Progetti for their new refinery at Danzig rather than to the Soviets whose secondary processing trails far behind that of Western Europe.

Table C-70

OIL AND REFINED PRODUCTS PRODUCTION AND TRADE IN POLAND
(Thousand Metric Tons)

	1960	1965	1970	1971
Crude Oil				
Crude oil production	194	339	424	395
Imports	714	3,218	7,011	7,894
Exports	-	-	-	-
Net internal supply	908	3,557	7,435	8,289
Refined Product				
Total refined product	796	3,461	6,844	7,626*
Imports	1,790	2,248	2,417	2.258
Exports	221	1,027	1,314	1,069
Apparent internal consumption	2,365	4,682	7,947	8,815

* Assuming 92 percent yield of liquid and solid product on crude.

Table C-71

REFINERY PRODUCT SLATE IN POLAND
(Percent of Total)

Product	1965	1970	1971
Gasoline	20.5%	23.7%	24.4%
Kerosene	3.8	2.2	1.0
Diesel fuel	26.5	32.7	34.4
Lubricating oil	5.3	3.9	*
Residual fuel oil	37.7	29.2	29.6
Other	7.2	8.3	10.6†
Total	100.0	100.0	100.0

* Included in "Other" products category.

† Including lube oils.

The supply and disposition of individual oil products is shown in Table C-72.

c. Oil Transport

Figure C-30 shows fuel transport in Poland.

All of the 424,000 tons of crude oil produced in Poland in 1970 was from the Eastern Beskidy fields in the region of Nowy Sacs (17) and Jaslo (20). All of the locally produced crude is transported by pipelines to local refineries.

In 1970 Poland imported 7.0 million tons of crude from the Soviet Union through the 48-inch Druzhba pipeline which runs 300 km from Brest (9) to the large refineries of Plock (18), and continues on to East Germany. Poland also imported 1.6 million tons of oil products from the USSR by rail along the 175 km run from Brest to Warsaw (6), from which it was distributed throughout the country. The total delivered cost of Soviet crude and oil products imported by Poland in 1970 was 143 million rubles. Poland also imported 800,000 tons of oil products by rail from Romania and exported 2.4 million tons of oil products in 1970.

6. Romania

a. Resources

All the main oil fields of the Carpathian region of Romania are in the southern oil province, an area of about 1500 square kilometers. This represents an exceptionally localized hydrocarbon accumulation. Oil occurs in Tertiary sediments, most of which have uncertain stratigraphic relationships, further complicated by complex tectonic patterns. Sandstones are the reservoir rocks, and there are numerous surface oil indications. The oil-bearing strata are shallow and poorly sealed, resulting in the surface seeps. Loss of lighter fractions through open

Table C-72

SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS IN POLAND
(Thousand Tons)

	1960	1965	1970	1971
Gasoline				
Production	121	708	1,623	1,862
Imports	85	860	1,000	
Exports	-	-	60	
Apparent consumption	206	1,568	2,563	
Kerosene				
Production	101	131E	149	71
Imports	50	54	20	
Exports	10	-	-	
Apparent consumption	141	85	169	
Diesel fuel				
Production	240†	916†	2,239†	2,623
Imports	760†	1,100†	1,100†	
Exports	190†	905†	1,160	
Apparent consumption				
Lubricating oil				
Production	142	184	269	n.a.
Imports	Included in "Other Products"			
Exports	Included in "Other Products"			
Apparent consumption				
Residual fuel oil				
Production	65	1,269	2,000	2,261
Imports	Included in "Diesel Fuel"			
Exports	Included in "Diesel Fuel"			
Apparent consumption				
Other products*				
Production	127‡	253‡	564‡	n.a.
Imports	895‡	234‡	297‡	
Exports	21‡	122‡	94‡	
Apparent consumption				
Total products				
Production	796	3,461	6,844	7,626§
Imports	1,790	2,248	2,417	2,258
Exports	221	1,027	1,314	1,069
Apparent consumption	2,365	4,682	7,947	8,815

n.a. - not available.

* Excluding LPG.

† Including residual fuel oil.

‡ Including lubricating oil.

§ Assuming 92 percent yield of liquid and solid product on crude.

E Estimated.

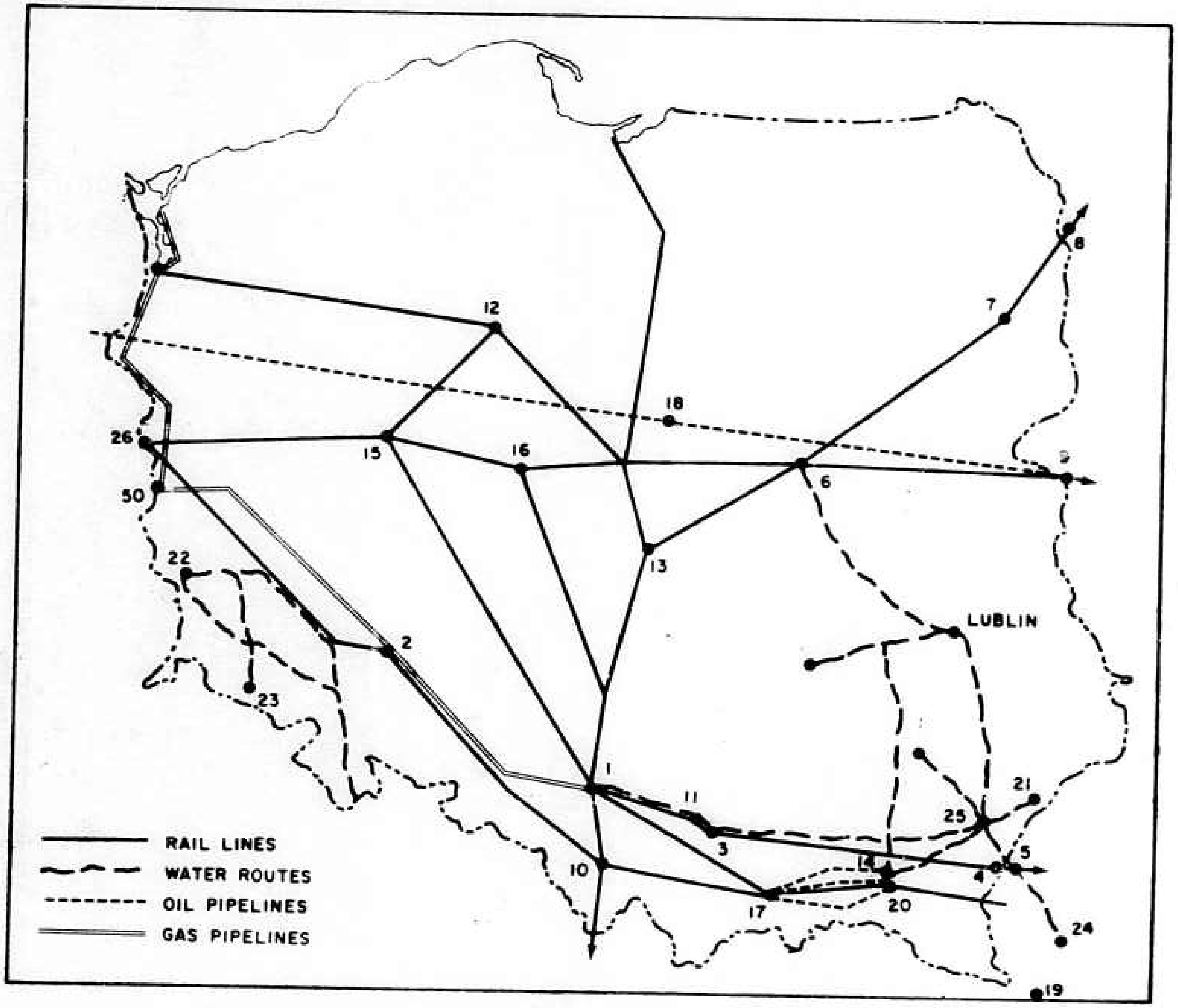

Figure C-30
FUEL TRANSPORT IN POLAND

communication with the surface has produced generally heavy, asphaltic oil in these deposits. In contrast, deeper, better sealed strata are richer in paraffin.

b. <u>Production, Refining, and Trade</u>

The Romanian oil processing industry is the only one in the Eastern bloc countries which has the capacity of not only satisfying its country's needs but also exporting much of its production. Although Romania is now self-sufficient in the internal oil balance, the manufacture of refined products requires sizable imports of crude petroleum. It does not import refined products nor export crude. The Romanian oil and oil products production and trade are presented in Table C-73; individual product disposition is shown in Table C-74. The biggest suppliers of crude to Romania in 1970 were Iran and Iraq, with smaller quantities coming from Syria and Libya. No oil is imported from the USSR at present.

The major oil refineries in Romania are Brazi (the biggest), Teleajen, Pitesti, Gheorghe Gheorghia-Dej (Onesti), Cimpina, Ploesti, Brasov, and Darmanesti.

The refining capacity was estimated to be approximately 16.0 million metric tons in 1970 (320,000 barrels per day). The growth in refining capacity can be seen in Table C-75. This was estimated by assuming approximately 92 percent yield on refinery charge.

No new refineries are now known to be under construction. However, plans exist for future construction of a refinery, perhaps of 3.0 million tons capacity near the Black Sea.

The petroleum product slate, in contrast to that of the USSR, favors motor fuels, as can be seen in Table C-76.

Table C-73

OIL AND REFINED PRODUCTS PRODUCTION AND TRADE IN ROMANIA
(Thousand Metric Tons)

	1960	1965	1968*	1970	1971
Crude oil					
Crude oil production	11,500	12,571	13,285	13,377	13,793
Imports	0	0	761	2,291	2,858
Exports	0	0	0	0	0
Net internal supply	11,500	12,571	14,046	15,668	16,651
Refined product†					
Total refined product‡	10,955	11,839	12,917	14,604	15,304
Imports	0	0	0	0	0
Exports	5,983	5,813	5,594	5,352	5,349
Apparent internal consumption	4,972	6,026	7,323	9,252	9,955

* From "Petroleum in Romania," API publication 2101, August 1971.

† Refined product yield was obtained by adding reported production for various products from Romanian Statistical Annual, 1971. Petroleum coke production was obtained from UN Series J publications. Petroleum coke production in 1971 was assumed to be the same as in 1970.

‡ Including all LPG produced in the country.

Source: Romanian Statistical Annual, 1971, Bucharest, 1972.

Table C-74

SUPPLY AND DISPOSITION OF PETROLEUM PRODUCTS IN ROMANIA
(Thousand Metric Tons)

	1967	1968	1969	1970
Gasoline				
Output	2,296	2,636	2,620	2,786
Exports	957	989	853	701
Apparent consumption*	1,339	1,647	1,787	2,085
Kerosene				
Output	923	949	1,004	969
Exports	215	180	201	91
Apparent consumption*	708	769	803	878
Diesel Fuel				
Output	4,025	4,368	4,593	5,049
Exports	2,091	2,288	2,160	2,548
Apparent consumption*	1,934	2,080	2,433	2,501
Lubricating Oil				
Output	544	595	598	606
Exports	371	358	380	349
Apparent consumption*	173	237	218	257
Residual Fuel Oil				
Output	3,946	3,624	3,915	4,249
Exports	1,790	1,678	1,400	1,532
Apparent consumption*	2,156	1,946	2,515	2,717
Other Products†				
Output	511	568	646	738
Exports	129	101	107	131
Apparent consumption*	382	467	539	607
Total Products†				
Output	12,245	12,740	13,376	14,397
Exports	5,553	5,594	5,101	5,352
Apparent consumption*	6,692	7,146	8,275	9,252

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* Includes civil and military consumption, additions to (or withdrawals from) storage, and losses.

† Includes asphalt, wax, petroleum coke, etc., but excludes LPG.

Table C-75

TRENDS IN REFINING CAPACITY IN ROMANIA

Year	Refining Capacity (million metric tons per year)
1960	12.0
1965	13.0
1968	14.0
1970	16.0
1971	17.0

Table C-76

REFINERY PRODUCT SLATE IN ROMANIA
(Percent of Total)

Product	1960	1965	1968	1970	1971
Gasoline	25.6%	21.0%	20.7%	19.4%	20.0%
Kerosene	11.8	8.2	7.4	6.7	7.0
Diesel fuel	21.8	30.7	34.3	35.1	35.0
Lube oils	2.9	4.2	4.7	4.2	4.0
Residual fuel oil	35.1	32.2	28.4	29.5	29.0
Asphalt	2.3	2.9	3.4	3.7	3.7
Others*	.5	.8	1.0	1.4	1.3
Total	100.0%	100.0%	100.0%	100.0%	100.0%

* Excluding LPG but including paraffin wax and coke.

The period between 1960 and 1965 was marked by expansion of secondary refining capacities and introduction of new refinery processes. The expansion of the Romanian petrochemical industry will require further expansion of secondary processing capability in refineries, as indeed seems to be happening at this time. The expansion of primary capacity does not feature strongly in Romanian plans. Table C-77 illustrates the secondary processing growth in Romania.

Table C-77

SECONDARY PROCESSING IN ROMANIAN REFINERIES

Process	Percent of Straight Run 1960	1965	1968
Straight run distillation	100.0	100.0	100.0
Vacuum distillation	9.6	20.0	21.3
Thermal cracking and visbreaking	28.3	25.2	19.7
Coking	0.6	5.9	6.0
Catalytic cracking	1.5	3.7	12.1
Catalytic reforming	-	9.0	12.6
Gas oil hydrofining	-	6.5	8.9
Absorption, gas and gasoline fractionating	-	8.6	7.8
Lube oil manufacture	2.8	4.0	4.4
Bitumen	2.2	2.8	3.2

Source: American Petroleum Institute.

The conclusions reached by a team of American observers on a visit to Romanian facilities in the latter part of 1970 were:

- The level of technical competence was fairly high.
- Much of the refinery equipment is manufactured in Romania and is of good quality.
- Because of increasing imports of crude with high sulfur content, the Romanians are faced with the necessity of installing additional secondary processing facilities. Romanian crude has a low sulfur content.
- Crude storage facilities were adequate to handle only a five day inventory. This seems to be the standard operating procedure of the Soviet refineries as well.
- Future expansion of refining will stress the production of feedstocks to the petrochemical industry.

c. Oil Transport

Figure C-31 shows fuel transport in Romania.

Of the 13.4 million tons of crude oil produced in Romania in 1970, about 3 million tons were produced in the Ottenian fields near Tingu-Jui (26), about 3.4 million in the Arges fields near Pitesti (17), about 5 million tons in the Ploesti (15) fields, and about 2 million tons in the northern Maldavian fields at Bacau (12). The main oil-refining cities are Ploesti and Bacau; about half of the crude produced in Romania is refined in these cities, and the rest is exported through the ports of Giurgiu (16), Galati (7), and Constanta (10). Pipelines connect all of the oil fields except Bacau with each of the above river and ocean ports.

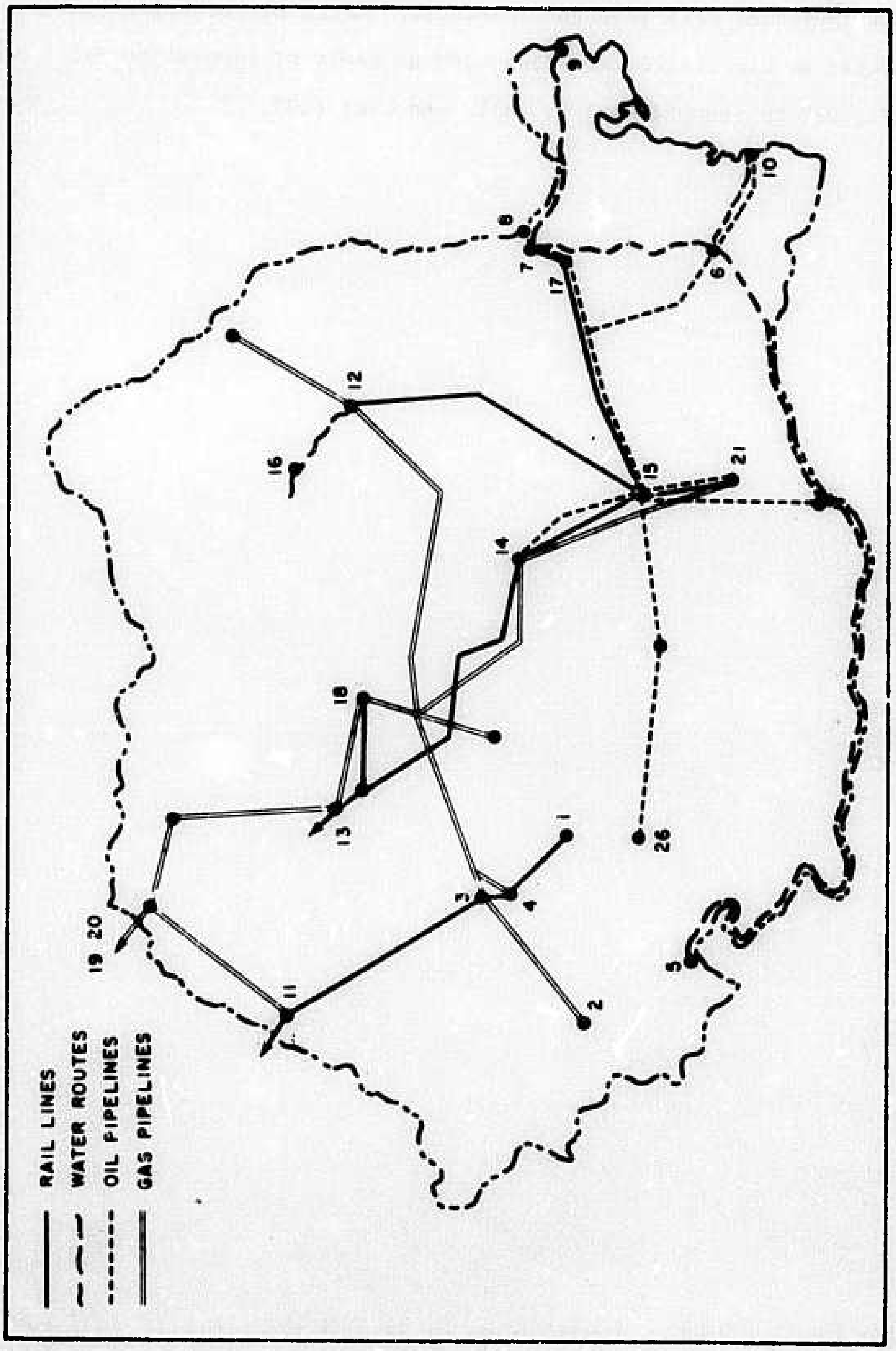

Figure C-31
FUEL TRANSPORT IN ROMANIA

Oil products from the refineries of Bacau and Ploesti are distributed by rail throughout Romania. Large petrochemical plants are located at Ploesti; Brasov (14), 100 km north of Ploesti by rail; Braila (17), 200 km from Ploesti by rail, and Cluj (13).

III PETROCHEMICAL INDUSTRY IN THE USSR AND EASTERN BLOC

A. Introduction

The petrochemical industry is being analyzed as a separate part of the industrial sector since energy in the form of hydrocarbons is consumed in large quantities as feedstock in addition to the quantities required for fuel and power requirements.

1. Technology Background

When viewed in total scope--that is, all of the processes and intermediate materials required for the plastics, films, synthetic rubbers, dyes, and paints--the petrochemical industry is vast and complex. Fortunately, however, this vast array of products and processes is based on a relatively small number of basic chemical feedstocks, which are produced by two types of process complexes:

- Olefins
- Aromatics

Olefins, of which the most important member is ethylene, are produced by high-temperature pyrolysis of hydrocarbon feeds ranging from ethane to gas oils. These hydrocarbons are provided from two major sources:

- Liquids condensed from natural gas
- Byproducts of refining crude oil

Petrochemical aromatics--benzene, toluene, and xylenes--are produced primarily by catalytically reforming the C_6 to C_8 components

of the naphtha derived from crude oil. Significant quantities of aromatics are also produced as a byproduct of coke production from coal.

Both olefins and aromatics are produced in refining crude oil for the production of gasoline and other fuel products. Olefins, however, are produced in significant quantity only where cracking is being employed in the refinery process. The ethylene thus produced is used as fuel if not recovered for chemical use, while the propylenes, butylenes, and pentylenes may be, and usually are, converted to gasoline by alkylation or polymerization. Typically, the requirements for ethylene far exceed the amounts available as refinery byproduct, which has resulted in the building of ethylene complexes separate from refinery facilities based on naphtha or natural gas liquids. The ethylene production of the USSR is an exception to this pattern, and in the rest of the world, the necessity of cracking heavier feedstocks when supplies of ethane, LPG, and naphtha become limited may result in future closer association of ethylene production and crude refining.

Reformate, a mixture of benzene, toluene, xylenes (BTX), and non-aromatics is produced by catalytic reforming in nearly all modern refineries as a necessary step for reaching gasoline octane requirements. Thus, petrochemical BTX production usually requires only the addition of extraction and purification facilities to an existing refinery. In addition to coke production byproduct, another important source of aromatics is the byproduct liquids (called Dripolene) resulting from ethylene production.

In addition to olefins and aromatics, a third chemical product, ammonia, accounts for a large quantity of hydrocarbon feedstock. In this instance, the hydrocarbon feedstock serves to provide the hydrogen required for ammonia synthesis, with the carbon rejected as CO_2, to be used for subsequent urea synthesis or vented. Natural gas (methane) is

the preferred feedstock, but naphtha and other hydrocarbons are used where natural gas is not available.

The vast majority of hydrocarbons used in the world's petrochemical industry are used in olefins, aromatics, and ammonia production. Thus, the data developed for analysis of the energy requirements are limited to these three categories.

2. Country-by-Country Analysis

In this section, the petrochemical industries of each of the East Bloc countries are analyzed with respect to the manufacturing capacities and locations of ethylene, BTX, and ammonia plants for the year 1970, along with feedstocks used, and estimated total energy consumption. The total energy consumption estimate is based on the net feedstock consumed, the fuel required for heat input, and the fuel for power generation. In the case of ethylene from naphtha, the total naphtha input is assumed to be consumed, and the fuel requirement is net of byproduct fuel gas. In the case of BTX production, the hydrocarbon consumption is taken to be the BTX volume per se, with other products of catalytic reforming of naphtha, light ends, and raffinate remaining in the refinery fuel products. Ethylene from refinery gas is treated similarly, with the assumption that cryogenic separation is used without additional pyrolysis.

B. USSR

Although the USSR has gained second place after the United States among the world's producers of chemicals, this position rests mainly on heavy chemicals production rather than petrochemicals. In fact, a substantial gap exists between the USSR and the majority of Western industrialized countries, as shown in the following comparison of

Soviet plastics and synthetic fibers output with those of the Federal Republic of Germany (FRG).[78]

	Kilograms per Capita (1970)	
	Plastics	Synthetic Fibers
USSR	7	0.7
FRG	71	10.0

Although the absolute production figures (Table C-78) for these petrochemical end-products place the USSR in a more respectable position, it is apparent that the development of petrochemicals has lagged behind the heavy chemical industry. Soviet planners have recognized this gap, as indicated by the goals of the current five-year plan to double output of plastics and synthetic fibers by 1975, while increasing total chemical output by 70 percent.

Given the substantial availability of basic raw materials, it is of interest to examine the factors that have influenced the growth of the Soviet petrochemical industry.

The first factor is that of choice; the Soviet planners of the five-year plans between 1928 and 1958 chose to give priority to production facilities for electric energy, steel, machinery, and heavy chemicals. Second, in the late 1950s, when emphasis was shifted to chemicals production, the plans did not provide for an adequate equipment industry to support chemical plant construction. A more recent problem relates to logistics. About 80 percent of the newly discovered hydrocarbon sources are located east of the Urals in undeveloped areas. The huge investments required to develop these resources have given the Soviets cause to seek partners both in the COMECON bloc and in the West.

Table C-78

SOVIET OUTPUT OF IMPORTANT INDUSTRIAL AND CHEMICAL PRODUCTS

	1950	1960	1965	1970	1975 (target)
Industrial product					
Electric energy (billion kWh)	91.2	292.3	506.7	740.4	1,065
Mineral oil (million tons)	37.9	147.9	242.9	352.6	496
Natural gas (thousand cubic meters)	6.2	47.2	129.4	199.6	320
Coal (thousand tons)	261.1	509.6	577.7	624.1	695
Steel (thousand tons)	27.3	65.3	91.0	115.9	146
Iron ore (thousand tons)	39.7	105.9	153.4	195.5	-
Chemical products					
Sulfuric acid (100% H_2SO_4) (thousand tons)	2.1	5.4	8.5	12.1	20
Soda (95%) (thousand tons)	749	1,887	2,871	3,668	4,933
Caustic soda (98%) (thousand tons,	325	765	1,303	1,938	2,610
Fertilizers (100% active substance) (thousand tons)	1.2	3.3	7.4	13.1	22
Commercial product (thousand tons)	5.5	13.9	31.3	55.4	90
Plant protectives (100% active substance)*	-	32.3	103.2	163.8	-
Commercial product	-	62.6	197.6	291.6	455
Plastics (thousand tons)†	67.1	311.6	802.9	1,672	3,533
Man-made fibers (thousand tons)	24.2	211.2	407.3	623.0	1,065
Synthetic fibers (thousand tons)	0.9	15.0	77.5	166.7	400
Synthetic detergents (thousand tons)‡	-	22.9	144	470	-
Soaps (40% fatty acid content (thousand tons)	816	1,451	1,782	1,442	-

* First statistics published in 1955 (14,900 tons).

† First statistics published in 1940 (10,900 tons).

‡ First statistics published in 1955 (1,200 tons).

Source: Chemische Industrie International, January 1973.

Given this relatively low level of petrochemical development in the USSR, the impact on energy resources is negligible. Although little explicit data are available on petrochemical feedstocks, the existing information suggests that byproducts of coke production and petroleum refining have been sufficient to provide the olefins and aromatics requirements. As shown in Table C-79, almost all of the 1970 ethylene capacity is based on recovery from refinery gas. Similarly, aromatics production is primarily based on coal-chemicals derived from coke production, as shown in the following tabulation.

Production of Aromatics

	Percent of Total					
	Coal			Oil*		
	1964†	1965	1970	1964	1965	1970
Benzene	97.0%	90%	70%	3.0%	10%	30%
Toluene	43.0			57.0		
Xylene	26.0			74.0		

* Based on catalytic reforming.

† From reference 79.

The trend to increased production of petrochemicals from oil is further substantiated by announced combines at Tomsk and Tobolsk, which will use natural gas, gas condensate, and oil products as feedstock to produce olefins and aromatics.

Ammonia production is similarly shifting to steam reforming based on natural gas feedstock to supplement the byproduct material from coke ovens. As shown in Table C-80, the transition to natural gas feedstock reached above 70 percent by 1970.

Table C-79

MAJOR PETROCHEMICAL CAPACITIES IN THE USSR
1970

Petrochemical by Location	Capacity (thousand tons/year)	Feedstock: Type	Feedstock: Estimated Consumption (thousand tons/year)	Total Energy Consumption (billion Btu/year)
Ethylene				
Kazan	60.8	Refinery gas	60.8	
Poletsk	[illegible].8	Refinery gas	40.8	
Ufa	[illegible].8	Refinery gas	55.8	
Total	157.4		157.1	13.3
BTX derivatives				
Etnylbenzene				
Donetsk	70	n.a.		
n.a.	70	n.a.		
n.a.	46	n.a.		
Cumene				
Grozny	83	n.a.		
Novokuibyshev	25	n.a.		
DMT				
Krasnoyarsk	54	n.a.		
Novomoskovsk	n.a.	n.a.		
Phenol				
Ostradn	n.a.			
Styrene				
Sterlitamak	n.a.			
Total	318			
Ammonia	6,750	n.a.		164

n.a. - not available

Table C-80

FEEDSTOCKS FOR AMMONIA PRODUCTION IN THE USSR BY TYPE
(Percent of Total)

	1958	1965	1969	1970
Natural gas	0.6%	54.9%	59.9%	73%
Coke oven gas	36.0	18.6	18.2	16
Coke and coal	44.9	17.8	15.2	3
Naphtha	–	–	–	5
Electrolysis, etc.	19.1	8.7	6.7	3

Table C-81 shows that natural gas feedstock for ammonia production was in the amount of some 160 billion Btu for the year 1970, equivalent to nearly 7 million tons.

Table C-81

NATURAL GAS CONSUMPTION FOR AMMONIA PRODUCTION

	Million Tons	Natural Gas Consumption, Feed and Fuel (10^{12} Btu/year)
1958	0.96†	0.2
1965	3.09†	56.3
1969	5.77*	114.7
1970	6.75‡	163.6

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* ECN report.

† Estimated at 17 percent annual growth.

‡ Soviet production indices based on 1970 production.

In a later 1971 report by Leonid Kostandou, Minister of the Chemical Industry, on the new five-year plan, he states that 95 percent of Soviet ammonia was being derived from natural gas.

C. Bulgaria

In common with the USSR and other East European countries, Bulgaria is currently in the process of converting its petrochemical industry from coal to a crude oil and natural gas basis. Indigenous reserves of natural gas have been discovered near Uratza, and crude oil deposits at Tyulenovo, Gigen, and Dolny Dabnik. Unfortunately, the reserves of oil and gas appear rather limited. Crude oil production peaked at 10,000 barrels per day in 1967 and has since declined. Natural gas production has also grown at a slower rate than expected, reaching 18 billion cubic feet in 1968 compared with a projected rate of 19 billion cubic feet from 1967. The outlook for natural gas in Bulgaria is perhaps best expressed by Russia's 1969 decision to build a natural gas pipeline to Bulgaria.

As shown in Table C-82, Bulgaria's production of petroleum-based chemicals other than fertilizers has been quite small prior to the current five-year plan. Two major petrochemical centers provide the major olefin and aromatic petrochemical feedstocks. A naphtha cracker at Burgas is being expanded to meet growth plans for olefin-based petrochemicals, along with recovery of byproduct aromatics. The major source of BTX materials is the refinery at Pleven (Table C-83).

D. German Democratic Republic

Having a large, well-established chemical industry, East Germany has not needed to implement crash expansion plans to provide its chemical product requirements. As shown in the production statistics in

Table C-82

CHEMICAL PRODUCTION IN BULGARIA 1960-1963
(Thousand Tons)

	1960	1966	1967	1968	1970*
Inorganic Chemicals					
Hydrochloric acid (31%)	0.7	7.6	10.2	13.9	-
Sulphuric acid	122.6	352.6	359.9	471.5	1,032
Ammonia (synthetic 100%N)	110.8	390.3	470.0	666.3	700
Aluminium sulphate	2.2	6.5	7.5	7.8	-
Calcium carbide	21.7	70.0	67.4	59.4	-
Caustic soda (98%)	17.8	38.7	42.1	43.0	-
Copper sulphate	10.3	11.6	12.5	13.8	-
Soda ash (98%)	131.0	230.3	222.5	229.1	327
Sodium bicarbonate	8.4	10.3	10.8	10.4	-
Fertilizers (gross weight)					
Nitrogenous fertilizers (other than Urea)	247.8	817.7	794.3	830.3	-
Ammonium nitrate	285.9	762.4	734.8	769.6	-
Ammonium sulphate	1.0	13.5	14.5	13.2	-
Ammonium solution	0.2	27.5	30.7	32.5	-
Sodium nitrate	10.6	14.3	14.3	14.9	-
Urea	4.3	58.4	192.2	493.0	-
Superphosphate	206.4	494.9	278.3	408.6	-
Other Chemical Products					
Glycerine	0.4	0.5	0.5	0.3	-
Pesticides (100% active content)	2.0	6.7	13.5	12.2	-
Aniline dyes	0.9	1.6	1.5	1.6	-
Plastics and resins	7.4	39.6	44.0	58.7	105
Zinc white	3.5	3.5	5.5	6.2	-
Tanning extracts	1.6	1.9	2.1	2.0	-

* Target.

Source: European Chemical News, February 5, 1971.

Table C-83

MAJOR PETROCHEMICAL CAPACITIES IN BULGARIA
(1970)

Petrochemical by Location	Capacity (thousand tons/year)	Type	Estimated Consumption (thousand tons/year)	Total Energy Consumption (billion Btu/year)
Ethylene				
Burgas	170	Naphtha	552	28.6
BTX derivatives				
Burgas	88	Dripolene	88	
Pleven	260	Reformate	260	
Total	348		348	22.6
Ammonia	970	n.a.		32.0

Table C-84, the chemical industry has experienced a slow but balanced growth, while gradually converting its plants from coal to petroleum feedstocks. East Germany has depended heavily on Russian crude supplies, until recent shortages have caused it to conclude agreements with Algeria and the United Arab Republic for additional crude oil.

As shown in Table C-85, the petrochemical industry has three major centers. A 150,000 barrel per day refinery at Schwedt in the north provides feedstocks to large olefin and aromatics facilities. At Leuna, in the south, a refinery-fertilizer complex includes a number of plastics and synthetic fiber plants. A third major complex, at Schkopau, produces acetylene-based synthetic rubber and plastics from the world's largest carbide plant.

Table C-84

PRODUCTION OF CHEMICALS IN EAST GERMANY
(Tons)

Chemical	1960	1967	1968	1969
Sulphur	112,000	123,000	119,000	109,554
Carbon disulphide	47,000	52,100	49,500	48,875
Sulphuric acid (H_2SO_4)	729,900	987,800	1,077,700	1,104,000
Caustic soda (NaOH)	327,000	389,000	450,000	394,086
Sodium sulphate (Na_2SO_4)	298,000	263,000	255,000	266,000
Soda ash (Na_2SO_3)	594,000	624,000	635,000	606,000
Hydrochloric acid (HCl)	74,700	74,500	75,000	75,000
Ammonia (NH_3)	477,000	550,000	559,000	593,000
Calcium Carbide	923,000	1,308,000	1,335,000	1,277,000
Potash fertilizer (K_2O)	1,666,000	2,206,000	2,293,000	2,346,000
Nitrogen fertilizer (N)	334,000	336,000	351,000	391,000
Ammonium sulphate (N)	178,000	160,000	167,000	152,634
Calcium ammonium nitrate (N)	122,000	120,000	145,000	155,484
Phosphatic fertilizers (P_2O_5)	166,000	305,000	346,000	369,000
Superphosphate (P_2O_5)	100,000	168,000	186,000	193,097
Methanol	73,000	119,000	122,000	135,000
Acetone	71,000	10,400	8,900	9,878
Acetic acid	51,300	107,500	117,400	123,842
Synthetic rubber	86,800	109,500	101,600	114,000
Chemical fibers	156,000	188,000	196,000	204,000
Plastics	n.a.	278,000	306,000	328,000
Caustic potash (KOH)	35,100	38,300	39,800	41,390

Source: "The Chemical Industry of East Germany," ECN Chemical Data Services, June 1971.
n.a. - not available.

Table C-85

MAJOR PETROCHEMICAL CAPACITIES IN EAST GERMANY (1970)

Petrochemical by Location	Capacity (thousand tons/year)	Feedstock Type	Feedstock (thousand tons/year)	Total Energy Consumption (billion Btu/year)
Ethylene				
Leuna	102	Naphtha		
Schwedt	100	Naphtha		
Total	202			33.9
BTX derivatives				
Erkner	45	Coke oven	45	
Schwedt	95		95	
Total	140		140	9.1
Ammonia	683	n.a.		22.5

n.a. -- not available.

E. Czechoslovakia

The growth of the petrochemical industry in Czechoslovakia has suffered from several adverse circumstances throughout the sixties. Lacking significant reserves of indigenous hydrocarbon resources, Czechoslovakia was totally dependent on Russian oil via the Druzhba pipeline until recent trade agreements with Iran and Iraq. Political problems following the 1968 invasion by Warsaw pact troops added to the ongoing political difficulties of separate Czech and Slovak interests.

The petrochemical production statistics shown in Table C-86 illustrate the general stagnation of the industry prior to the early 1970s. Further, the ethylene, BTX, and ammonia capacities in place in 1970 (Table C-87) were of marginal economic size, but served to develop the infrastructure for subsequent major expansion.

Table C-86

CHEMICAL PRODUCTION IN CZECHOSLOVAKIA
(Thousand Tons)

Chemical	1966	1967	1968	1969	1970
Sulphuric acid	982	1,012	977	1,029	n.a.
Nitrogen fertilizers	251	245	262	299	249
Phosphate fertilizers	261	274	264	289	267
Plastics	152	185	197	210	n.a.
Chemical fibers	83	89	89	94	n.a.

n.a. - not available.

Source: "The Chemical Industry of Czechoslovakia," ECN Chemical Data Services, June 1971.

Table C-87

MAJOR PETROCHEMICAL CAPACITIES IN CZECHOSLOVAKIA
(1970)

Location	Capacity (thousand tons/year)	Feedstock Type	Feedstock (thousand tons/year)*	Total Energy Consumption (billion Btu/year)*
Ethylene				
Bratislava	60	Refinery gas	60	
Mdst-Zaluzi	60	Refinery gas	60	
Total	120			10.1
BTX derivatives				
Bratislava	190	Reformate and Dripolene		12.4
Ammonia	650	n.a.	n.a.	21.4

n.a. - not available.

* Estimated.

In the current five-year plan, the ethylene capacity at the Slovnaft complex (Bratislava) has grown to 220,000 tons per year, with a new 200,000 ton-per-year plant being constructed by Humphries and Glasgow based on Russian naphtha.

F. Hungary

Prior to 1950, Hungary was predominantly an agricultural economy with little industrial development. Expansion of Hungary's chemical industry began to receive emphasis in the early 1960s, with primary focus on fertilizer production. Discoveries of oil in the Nagylengyel field in the early 1950s and of oil and gas in the Szeged fields in the mid-1960s contributed to the total 1969 rates of 37,000 barrels per day of crude oil and 340 million standard cubic feet per day of natural gas.

As shown in Table C-88, the growth of hydrocarbon-based chemicals other than ammonia was very slow in the early 1960s. However, as in other East Bloc countries, the investment plans call for greatly increased expansion of the petrochemical sector. Olefin production is to receive particular emphasis, based on feedstocks produced by gas processing facilities being constructed at Szeged and a new refinery planned for Szazhablombatta to process Russian crude. Plans also include expansions of the existing ethylene plant at Leninvaros (Table C-89) and BTX operations at Szony.

G. Poland

In common with the general pattern of the East Bloc chemical industry, Poland is shifting its emphasis from fertilizers and heavy chemicals to petrochemical products, especially plastics and synthetic fibers. Poland established a relatively early base in the early 1960s with the

Table C-88

PRODUCTION OF CHEMICALS IN HUNGARY
(Thousand Tons)

Chemical	1960	1967	1968	1969	1970
Sulphuric acid	164	424	446	454	457
Caustic soda	17	56	52	56	69
Ammonia	n.a.	288	347	n.a.	506
Nitrogen fertilizers	278	901	1,196	1,464	1,708
Phosphate fertilizers	266	824	846	917	900
Plastics	-	36	43	39	55
Chemical fibers	-	9	9	10	10

n.a. - not available.

Source: "The Chemical Industry of Hungary," ECN Chemical Data Services, June 1971.

Table C-89

MAJOR PETROCHEMICAL CAPACITIES IN HUNGARY
(1970)

Location	Capacity (thousand tons/year)	Feedstock Type	Feedstock (thousand tons/year)	Total Energy Consumption (billion Btu/year)
Ethylene				
Leninvaros	25	Naphtha	81.2	4.2
BTX derivatives				
Szony	20 (plan)	Reformate	20	1.3
Ammonia	507	n.a.		16.7

n.a. - not available.

refinery and petrochemical complex at Plock. As shown in Table C-89, this petrochemical complex provided the base for substantial development of the plastics and artificial fibers sectors prior to 1965.

In addition to significant reserves of natural gas (90 million cubic feet produced in 1968), Poland has the commercial advantage of seaports on the Baltic Sea. Indigenous crude oil provides only about 10 percent of Poland's requirements, with the balance supplied by Russia via the Friendship (Druzhba) pipeline.

Table C-90

PRODUCTION OF MAJOR CHEMICALS IN POLAND
(Tons)

Chemical	1965	1968	1969	1970
Sulphur ore	2,959,000	2,898,000	2,955,000	4,031,000
Elemental sulphur	431,000	1,316,000	1,942,000	2,684,000
Sulphuric acid	1,062,000	1,314,000	1,516,000	1,916,900
Soda ash	614,000	637,000	641,000	657,000
Sodium hydroxide	224,000	307,000	324,000	325,000
Carbide	488,000	522,000	522,000	533,000
Fertilizers	3,315,000	4,921,000	5,629,000	n.a.
Nitrogen (N)	394,000	759,000	938,000	1,031,400
Phosphoric (P_2O_5)	344,000	474,000	534,000	600,000
Synthetic rubber	39,200	40,800	48,100	61,700
Artificial fibers	104,000	124,000	131,000	138,000
Plastics	118,000	199,000	240,000	265,700
PVC	26,400	50,200	75,200	85,000

n.a. - not available.

Source: "The Chemical Industry of Poland," ECN Chemical Data Services, June 1971.

In addition to the petrochemical complex at Plock, a second major complex is being developed at Blachownia, expanding the ethylene capacity shown in Table C-91 to 300,000 tons per year. The current five-year plan calls for doubling the crude oil capacity to 14,000 tons per year (280,000 barrels per day) from the 1970 consumption, with corresponding increases in plastics and synthetic fibers.

Table C-91

MAJOR PETROCHEMICAL CAPACITIES IN POLAND
(1970)

Location	Capacity (thousand tons/year)	Feedstock Type	Feedstock (thousand tons/year)	Total Energy Consumption (billion Btu/year)
Ethylene				
Blachownia	65	Naphtha	211	
Plock	67	Naphtha	218	
Total	132		429	19.3
BTX derivatives				
Blachownia	85	Reformate	85	
Plock	235	Reformate	235	
Total	320		320	20.8
Ammonia	1,840	n.a.		60.9

n.a. - not available.

H. Romania

From its position as third largest chemical producer of the East Bloc countries, Romania has entered its current ambitious five-year plan from a strong base. Given its long history of strength in petroleum resources, Romania has developed a strong position in petrochemicals as well as in heavy inorganic chemicals (Table C-92). The present petrochemical industry is based around three major centers at Pitesti, Ploesti, and Borzesti. Basic raw materials from these three centers support a network of nine large petrochemical complexes. This network was developed in less than 10 years, in part because of Romania's willingness to acquire Western materials and technology during the 1960s.

Although traditionally a supplier of crude oil and natural gas to other countries, Romania's crude production leveled out at about 270,000 barrels per day from 1968 to 1970, causing Romania to enter into long-term crude oil supply agreements with Venezuela, Iran, and Saudi Arabia. Natural gas production continued to climb in the late 1960s, to 620 billion standard cubic feet in 1969, but import of Russian gas is anticipated in the 1970s.

The current five-year plan calls for emphasis on consumer-oriented finished products, with targets of tripling 1970 ethylene capacity (Table C-93) by 1975 and an overall growth rate of 15 percent per year in chemicals.

Table C-92

CHEMICAL PRODUCTION IN ROMANIA
(Tons)

Chemical	1967	1968	1969	1970
Fertilizers (nutrient)	537,000	603,000	720,000	1,346,000
N	372,000	421,000	494,000	644,200
P_2O_5	165,000	182,000	221,000	244,200
Plant protection agents	25,047	25,398	24,619	n.a.
Synthetic rubber	51,275	53,962	55,207	61,200
Plastics	108,000	130,000	137,000	241,000
Sulphuric acid	679,000	773,000	838,000	994,000
Detergents	5,926	5,948	6,397	8,000
Benzene	63,500	63,804	86,596	113,200
Toluene	66,673	66,516	79,923	117,000
Zylene	51,710	55,835	86,752	118,000
Chemical fibers	47,300	53,491	56,407	83,000
Artificial fibers	39,305	43,942	39,020	47,000
Synthetic	7,995	9,549	17,387	29,500
Caustic soda	260,000	275,000	312,000	317,400
Soda ash	384,000	471,000	595,000	588,000

n.a. - not available.

Source: "The Chemical Industry of Rumania," ECN Chemical Data Services, June 1971.

Table C-93

MAJOR PETROCHEMICAL CAPACITIES IN ROMANIA
(1970)

Location	Capacity (thousand tons/year	Feedstock Type	Feedstock (thousand tons/year)*	Total Energy Consumption (billion Btu/year)
Ethylene				
Brazi/Ploiesti	35	Naphtha	114	
Pitesti	100	Naphtha	325	
Total	135		439	22.7
BTX derivatives				
Brazi/Ploiesti	420	Reformate	420	
Pitesti	65	Dripolene	65	
Coal-based	60		60	
Total	545		545	35.4
Ammonia	1,333	n.a.		44.0

n.a. - not available.

* Estimated.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to conduct an analysis of the energy resources and programs of the Soviet Union and Eastern Europe and their relationship to the rest of the world. ~~A survey~~ was made of energy development technology which included exploration, development, production, distribution, storage and utilization of energy and new forms of energy. Also, an appraisal was made of recent resource recovery and research and development of energy conversion technology, distribution, and utilization (Over)

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BLOCK 20. Abstract (Continued)

efficiency. The economic aspects of energy developments and use were discussed as related to patterns of consumption, trade, and the Gross National Product of the Soviet Union and Eastern European countries. The overall energy supply and demands of these countries were projected to the 1980 and 1990 time frames. Finally an analysis was made of the Soviet political/military/energy strategy policies relative to the economic impact on Eastern and Western Europe.

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This appendix examines the geophysical characteristics of oil deposits in the Soviet Union and estimates the magnitude of Soviet oil resources and reserves and oil resources of Eastern Europe.

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